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A Study Comparing Water Usage from Three Electric Generating Capacity Expansion Alternatives for the Western United States

by

Thomas Veselka, Guenter Conzelmann,
John Gasper, Vladimir Koritarov, and Les Poch from
Argonne National Laboratory (ANL)

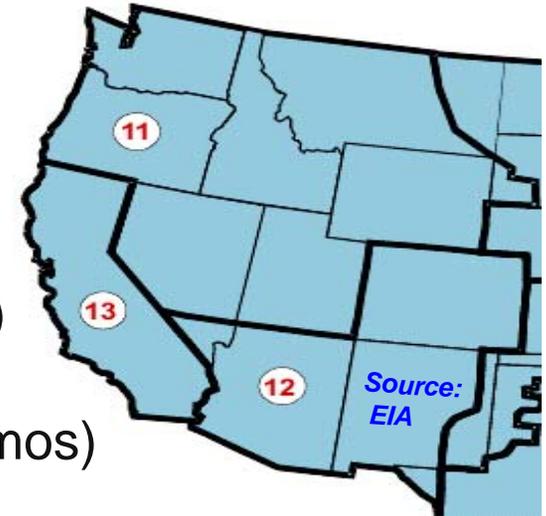
presented at the

**2008 Western Conference
of Public Service Commissioners Conference
June 17, 2008**

Whitefish, Montana

Western U.S. Water Usage Project Overview

- Project scope and objectives
 - Project fresh water withdrawals & consumption
 - Electric sector thermal power production
 - Analysis period is from 2005 to 2025
 - Western Electricity Coordinating Council (WECC)
- Project Participants
 - Three DOE laboratories (ANL, Sandia & Los Alamos)
- ANL Methodology
 - Hourly loads and monthly load duration curves (LDC)
 - Unit-level thermal power plant operations
 - Hydropower plants operations represented as a two-block aggregate resource
 - Power systems approach
- Scenarios
 - Base Case
 - High (Max) Nuclear
 - High (Max) Renewable



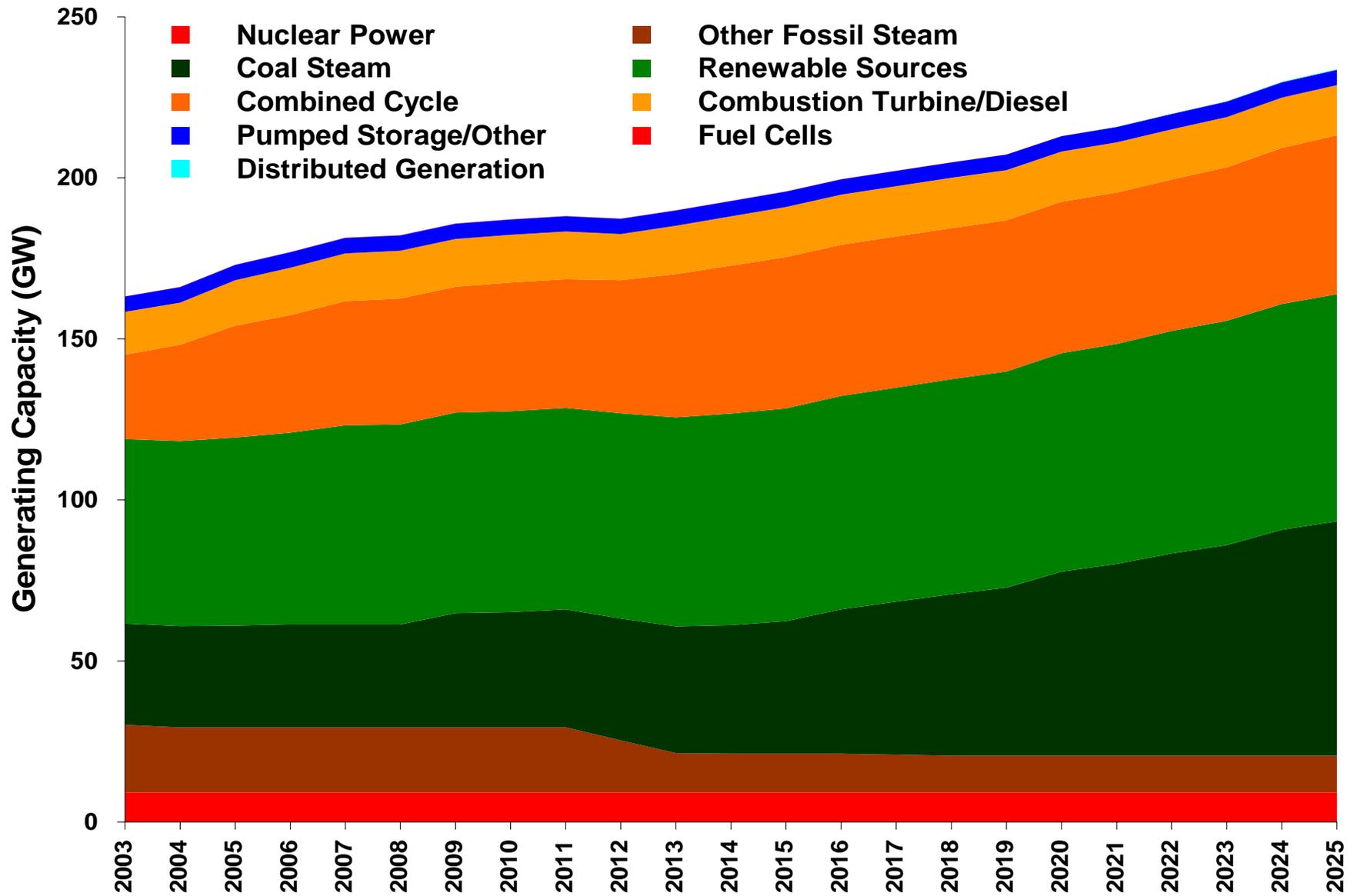
ANL Modeling Methodology

- Obtained data from publicly available sources – EIA, FERC, and NERC
 - Hourly Loads – FERC 714
 - Unit inventory – EIA 860 (2005 data)
 - Fuel prices – EIA 423
 - Heat rates – EIA 906 and 767
 - Water use and FGD units (existing units) – EIA 767
 - Unit outages – Generation Availability Data System (NERC)
 - Water use (future units) – NETL (DOE/NETL-2006/1235)
- Generation from non-dispatchable units (hydro and renewable) were subtracted from loads using ANL-developed model.
- Used a probabilistic simulation dispatch model to determine generation of dispatchable thermal units
- Added capacity to meet 15% reserve margin
- Main expansion candidates included: 600-MW coal, 400-MW NGCC, 230-MW GT, 1000-MW Nuclear

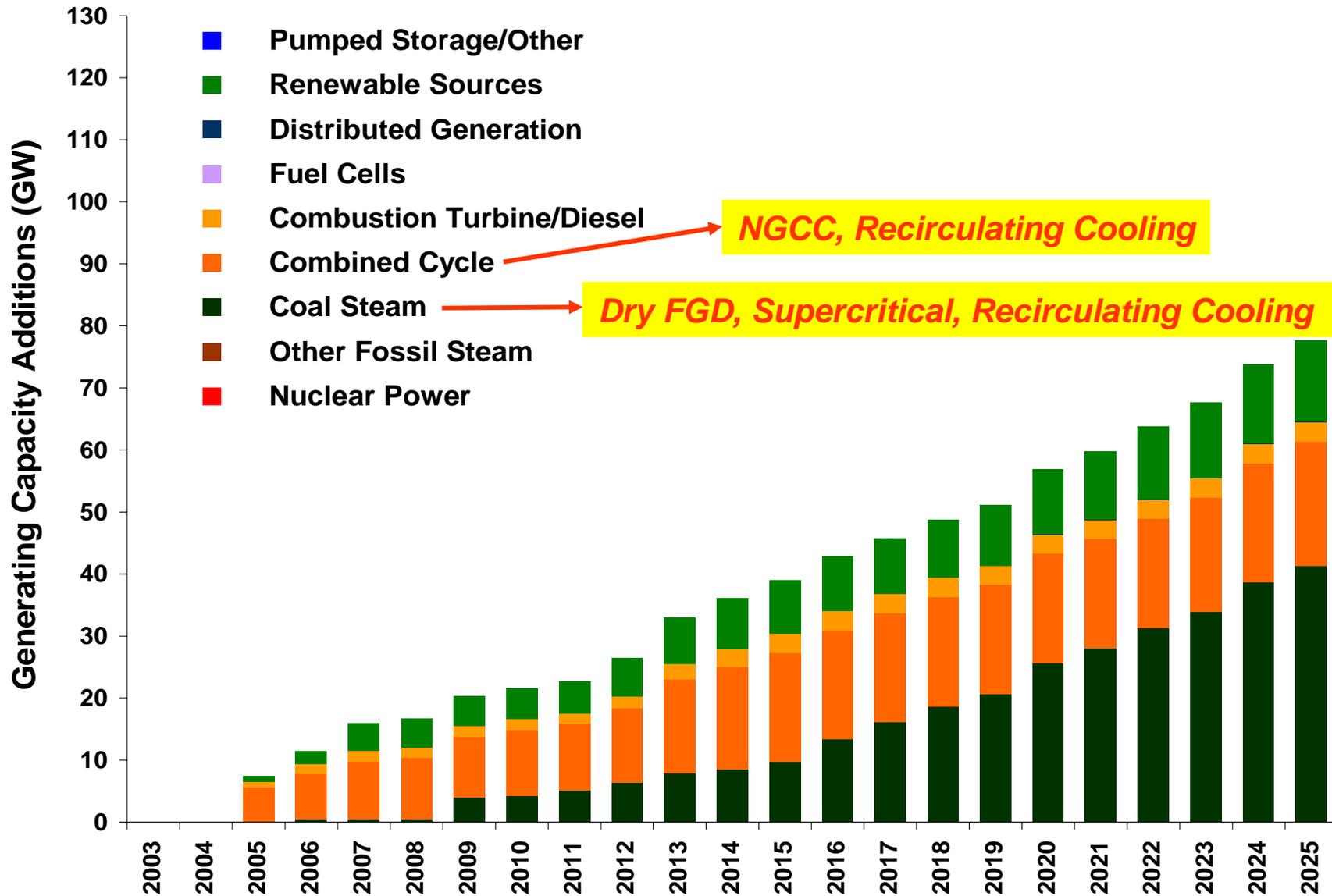
Base Case Scenario

2006 Annual Energy Outlook

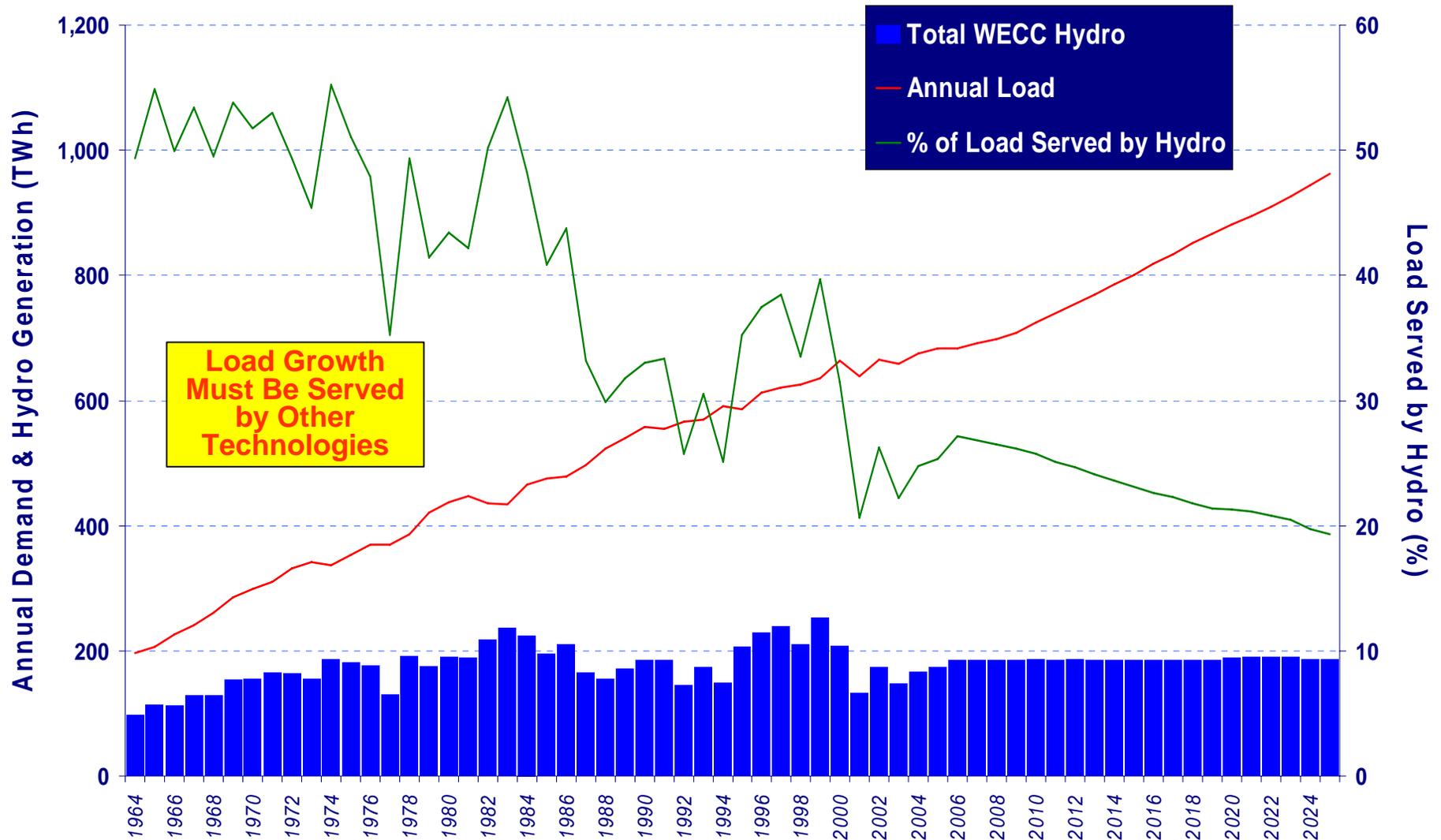
Base Case Total Capacity



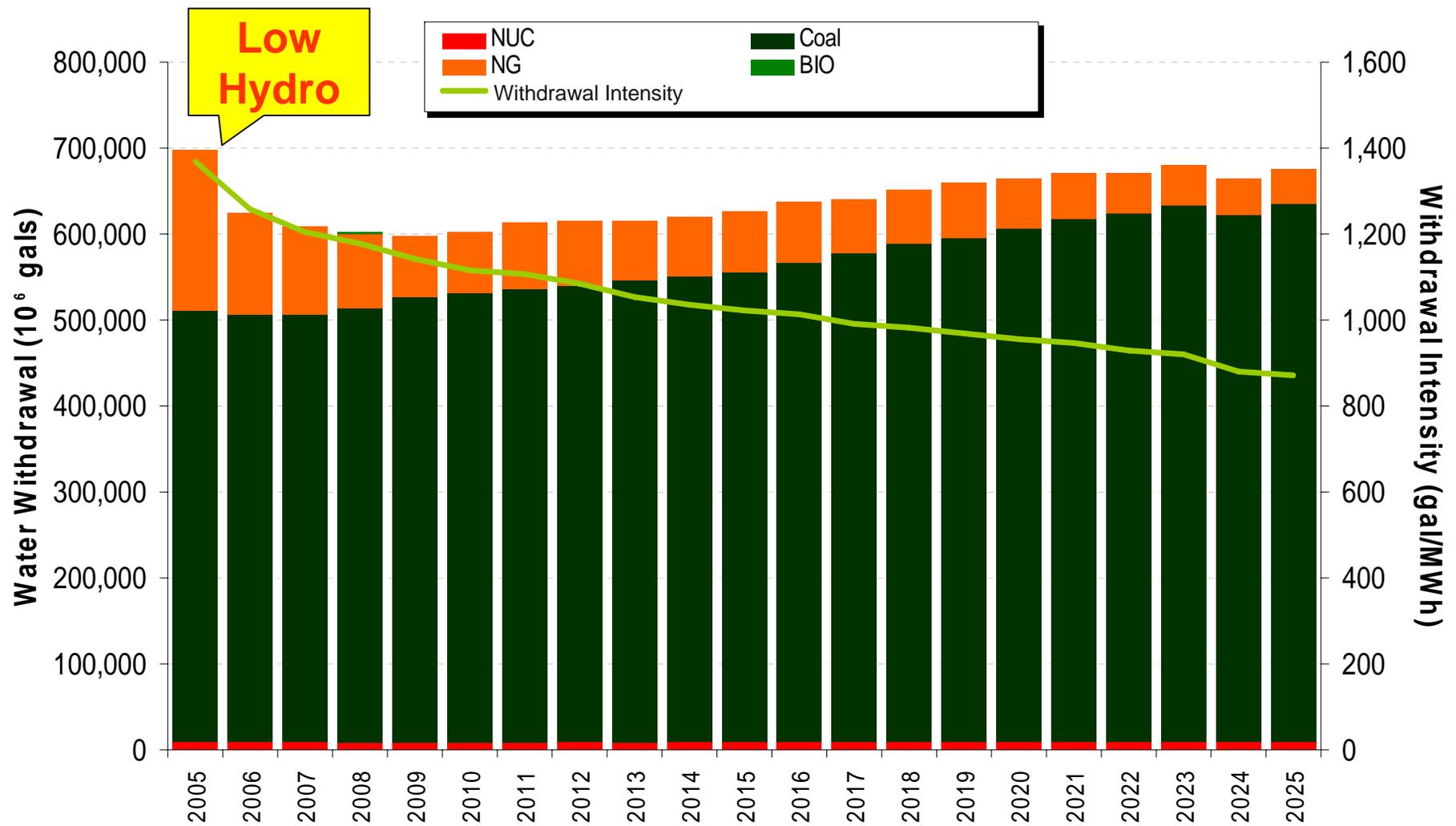
Base Case Cumulative Capacity Additions



Hydropower Will Serve a Decreasing Portion of the WECC Load



Base Case Annual Water Withdrawal

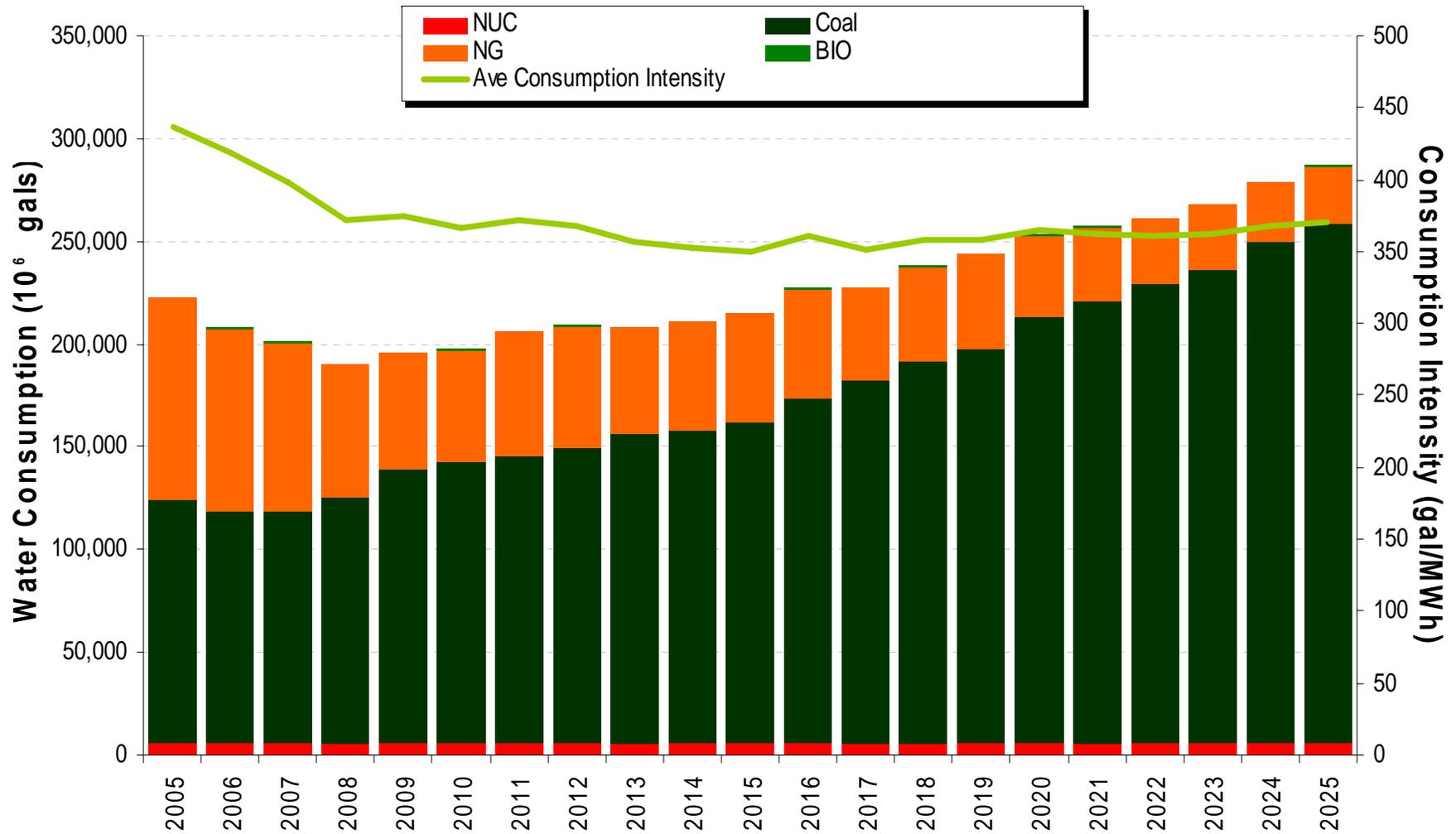


New Coal: 648 gal/MWh

New NGCC: 150 gal/MWh

Water Factors from NETL

Base Case Annual Water Consumption



New Coal: 496 gal/MWh

New NGCC: 130 gal/MWh

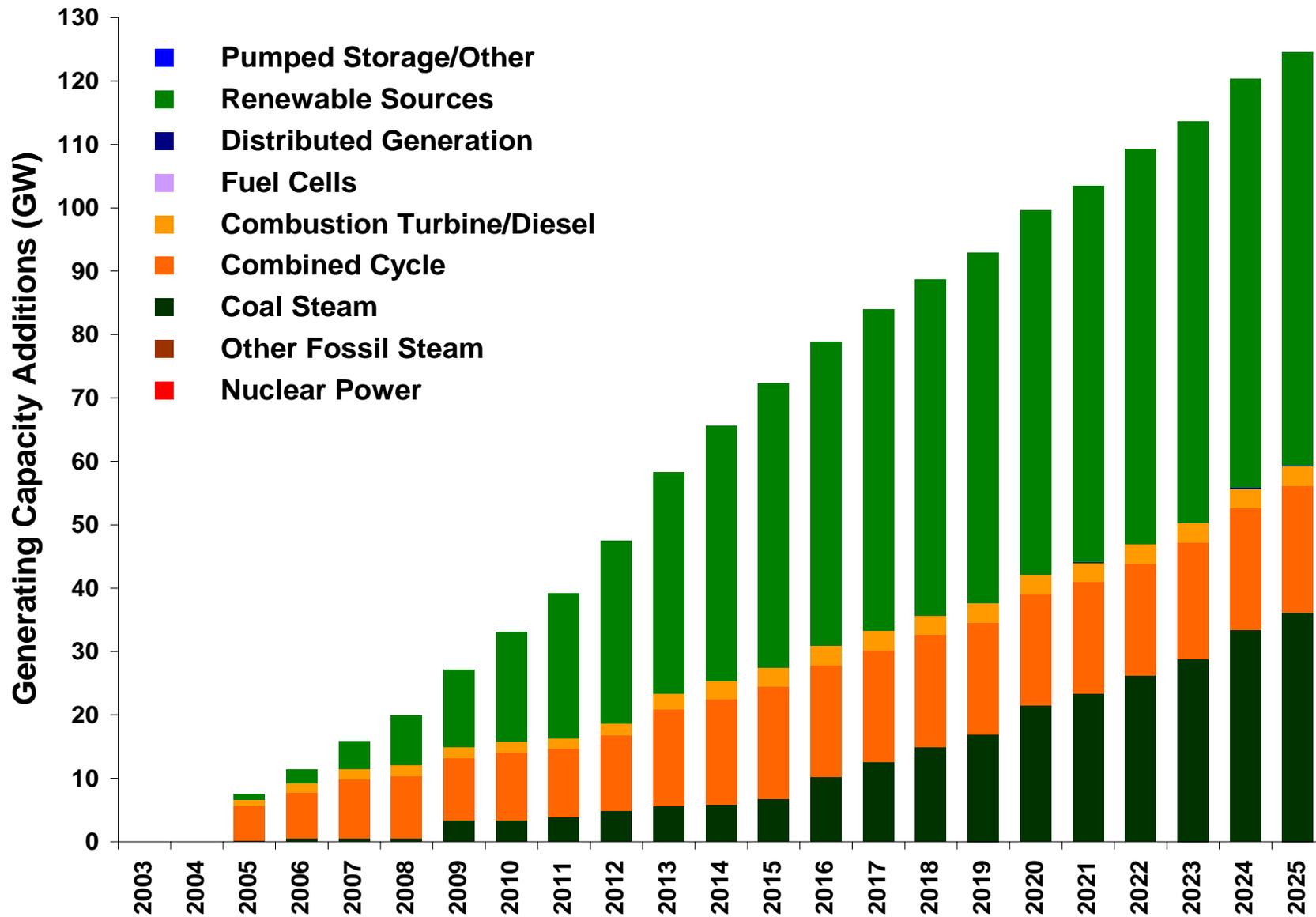
Water Factors from NETL

High Renewable Scenario

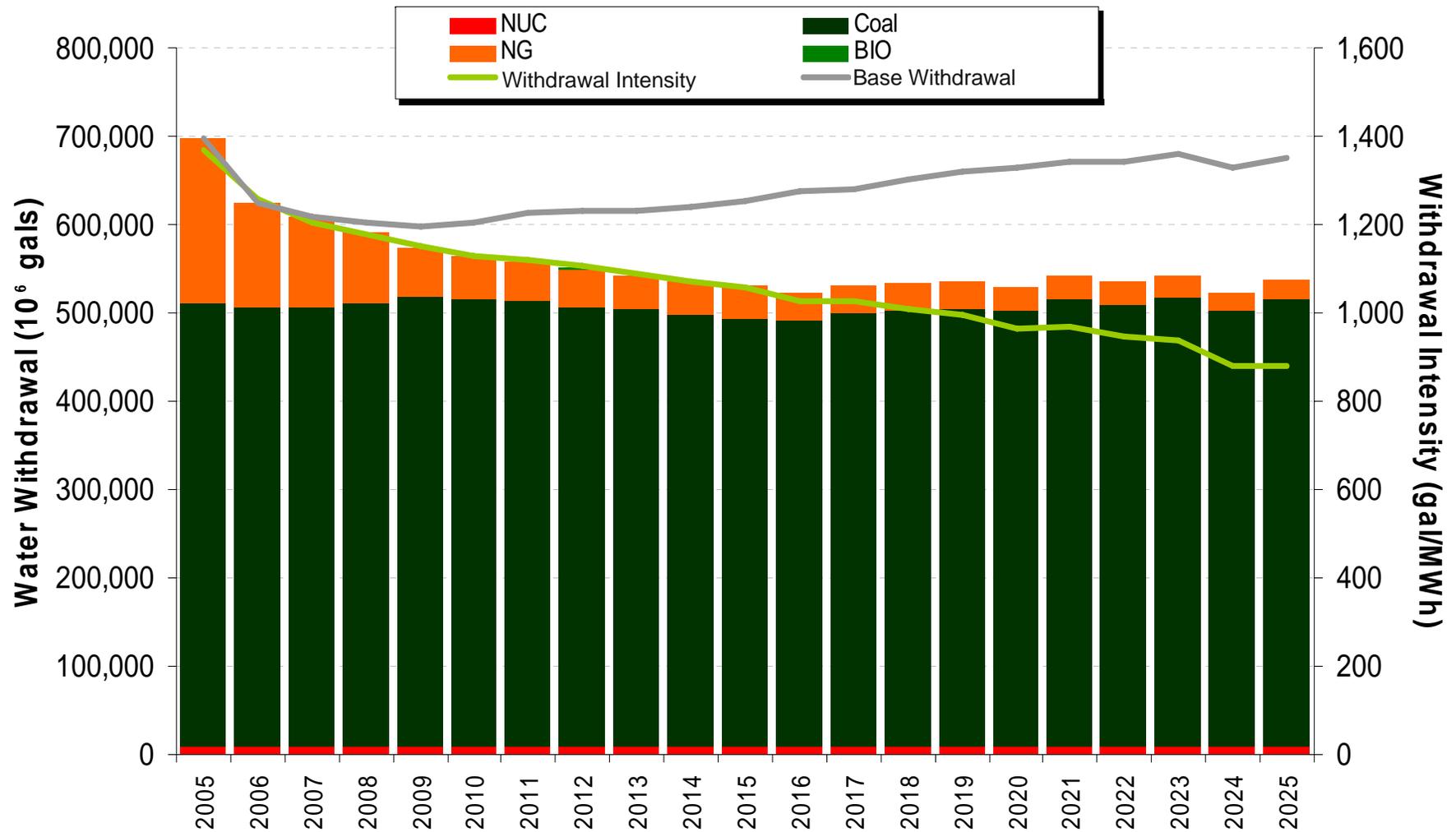
***25% of Load Served by
Renewable Energy Sources***

***Primarily New Wind Turbines
(about 90%)***

High Renewable Scenario Cumulative Capacity Additions



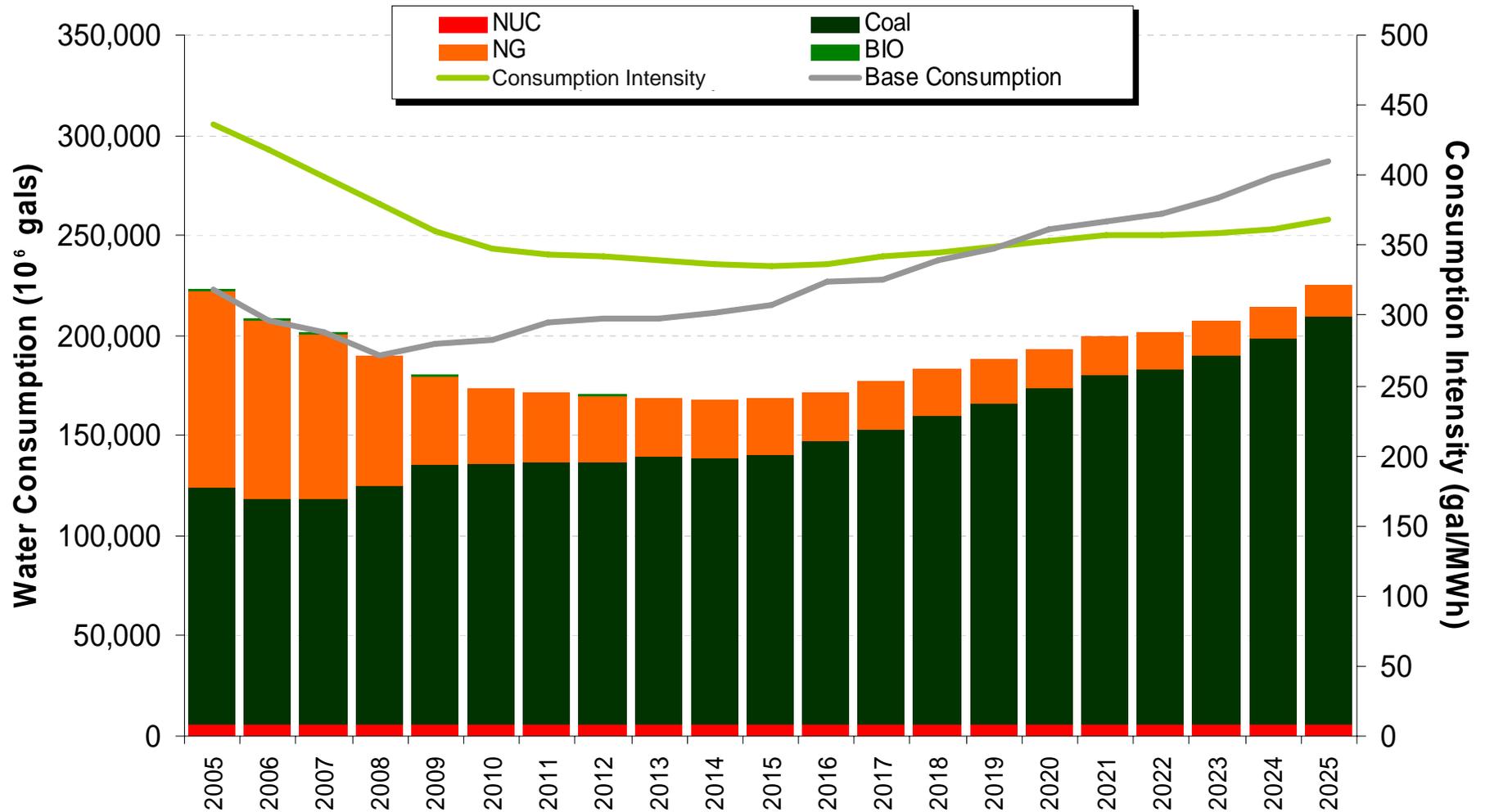
High Renewable Scenario Annual Water Withdrawal



New Coal: 648 gal/MWh

New NGCC: 150 gal/MWh

High Renewable Scenario Annual Water Consumption



New Coal: 496 gal/MWh

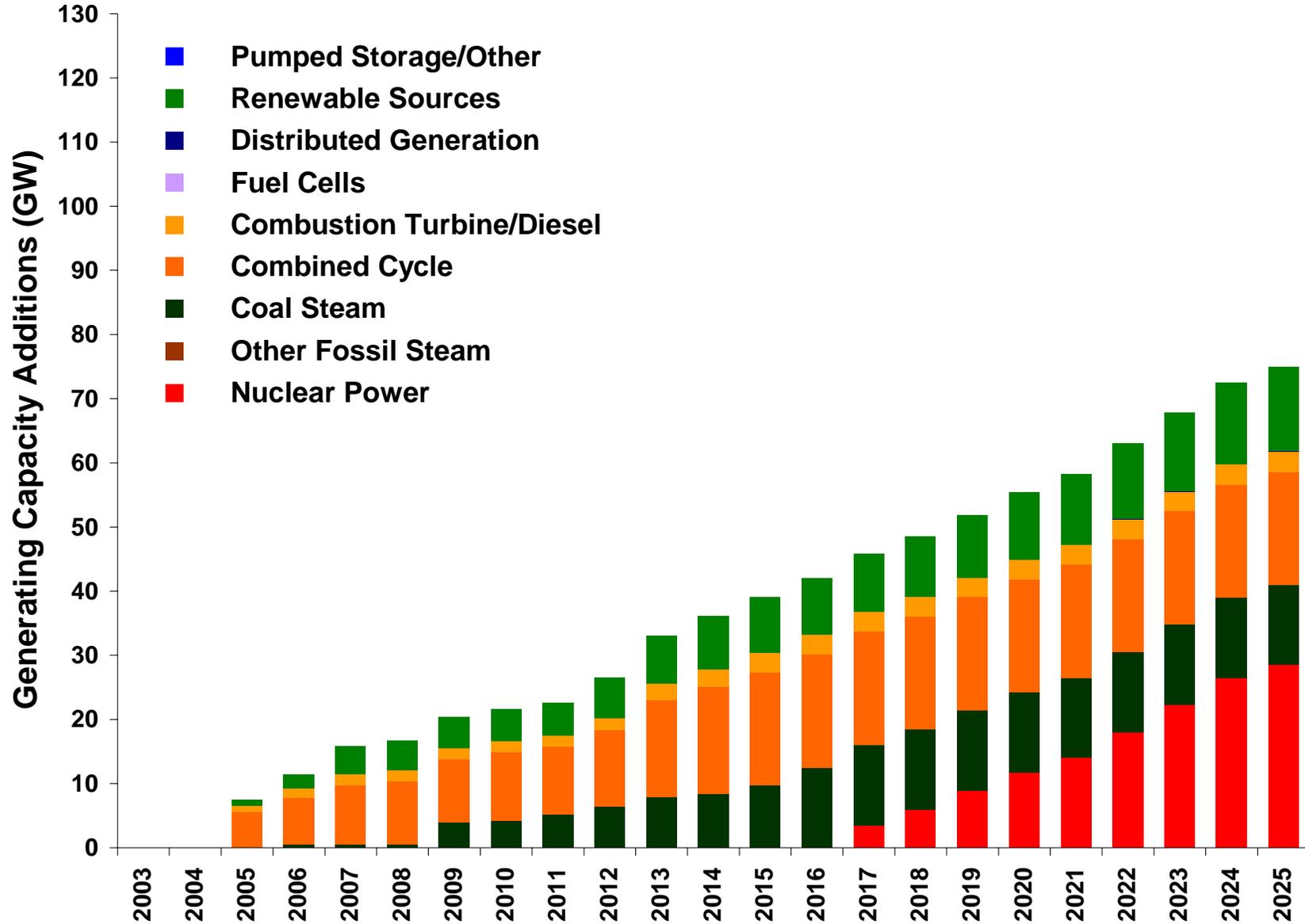
New NGCC: 130 gal/MWh

High Nuclear Scenario

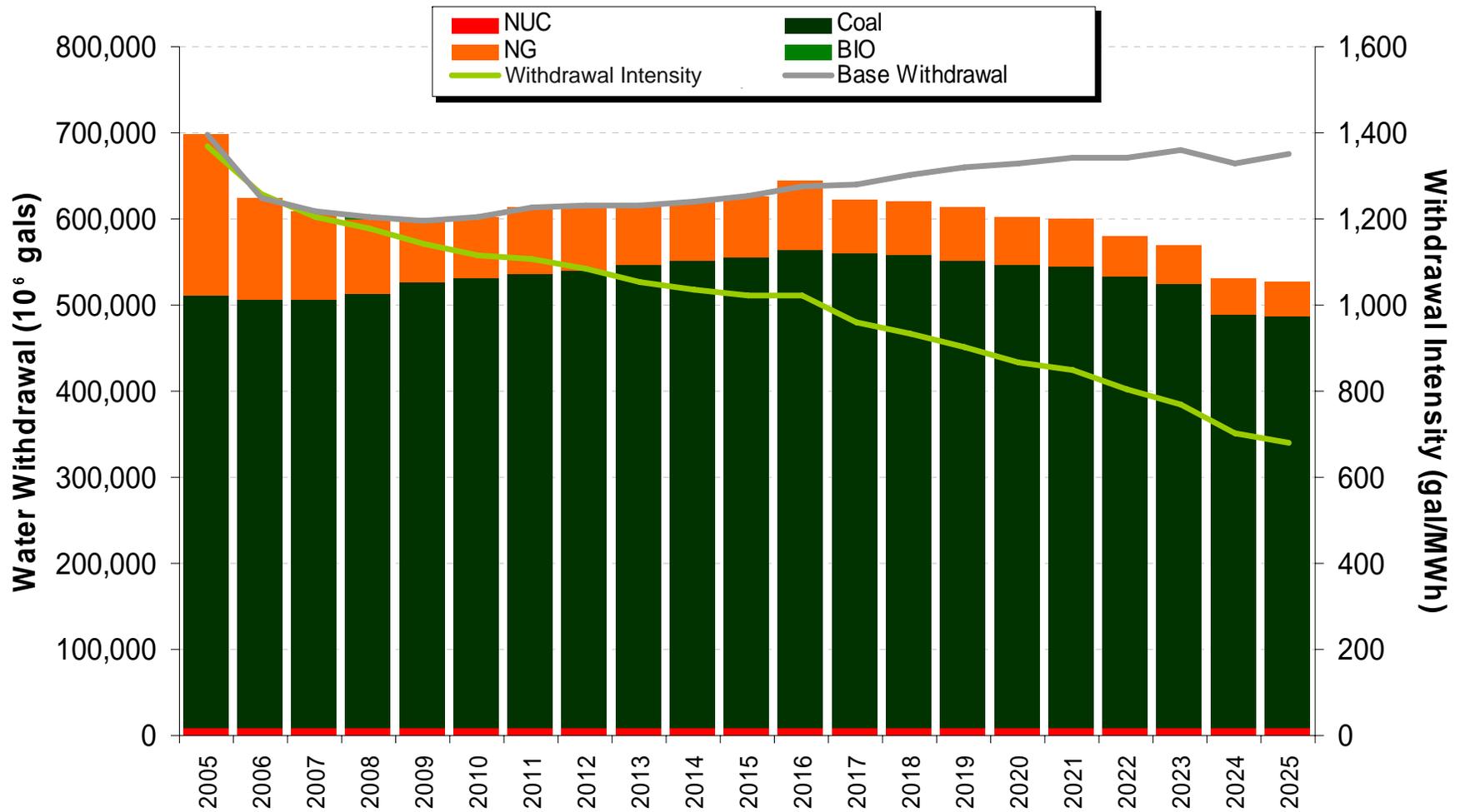
**50% of New Capacity Will
Eventually be Nuclear**

Zero Fresh Water Withdrawal & Consumption

High Nuclear Scenario Cumulative Capacity Additions



High Nuclear Annual Water Withdrawal

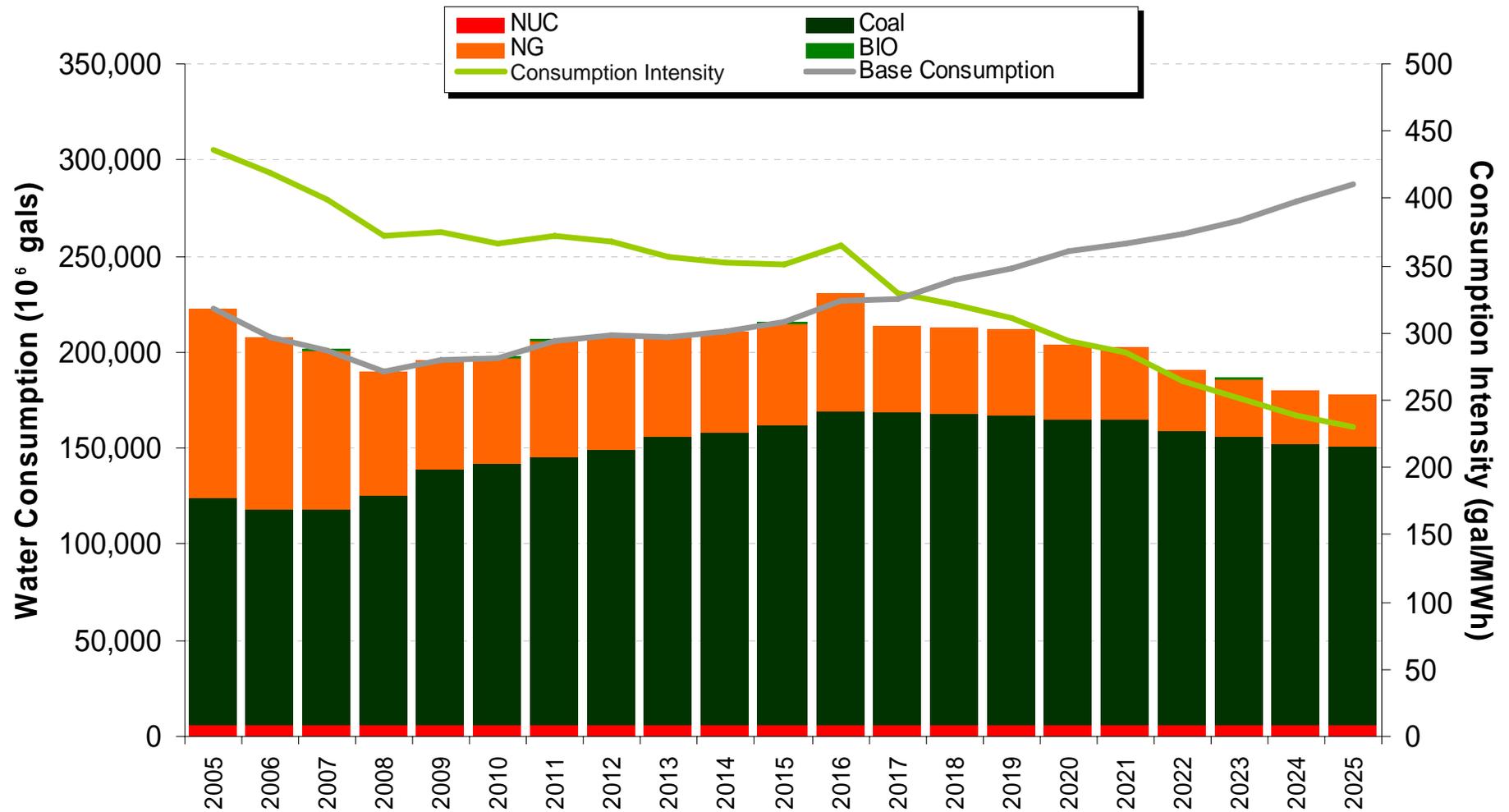


New Coal: 648 gal/MWh

New NGCC: 150 gal/MWh

New Nuclear: 0 gal/MWh

High Nuclear Annual Water Consumption

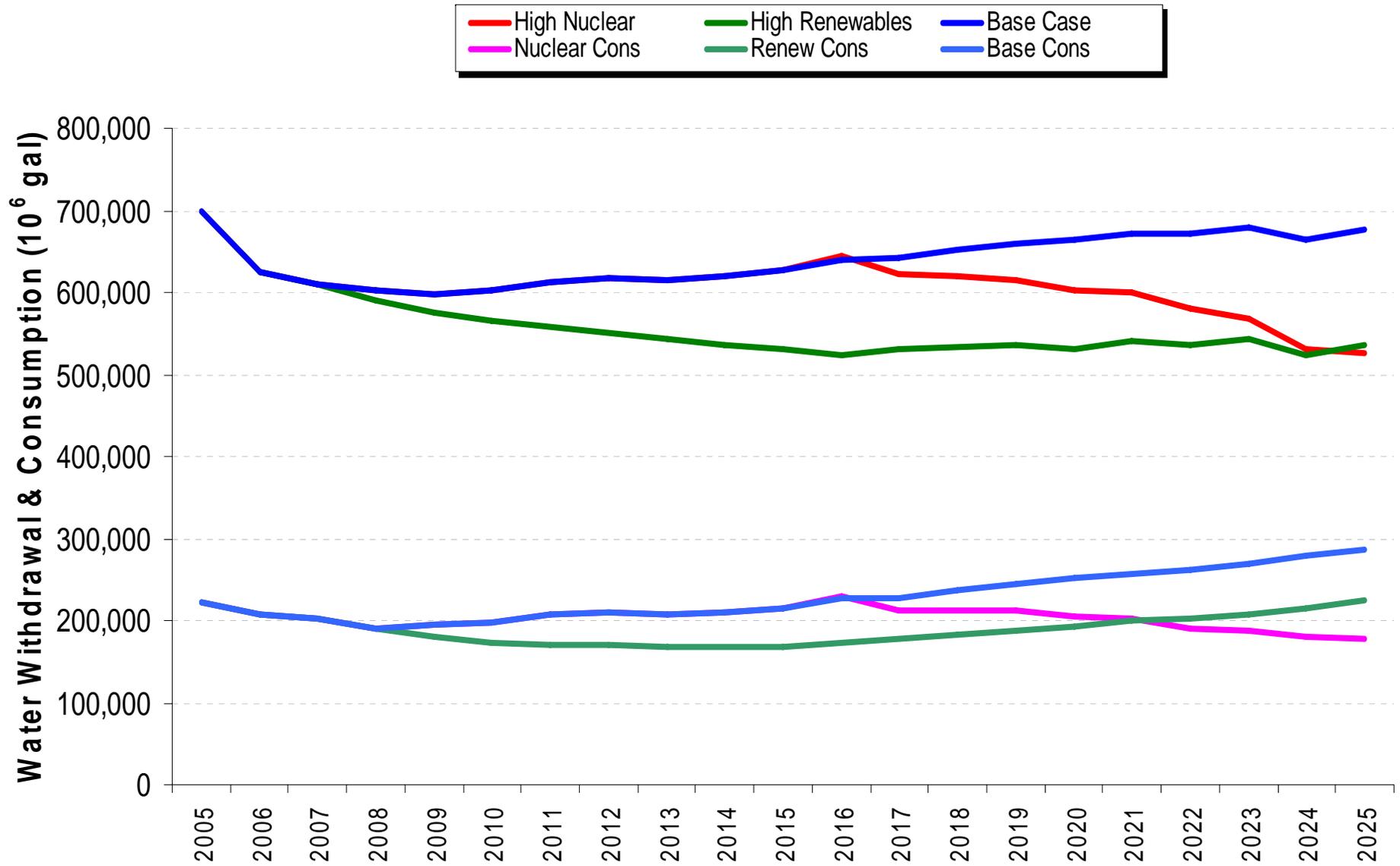


New Coal: 496 gal/MWh

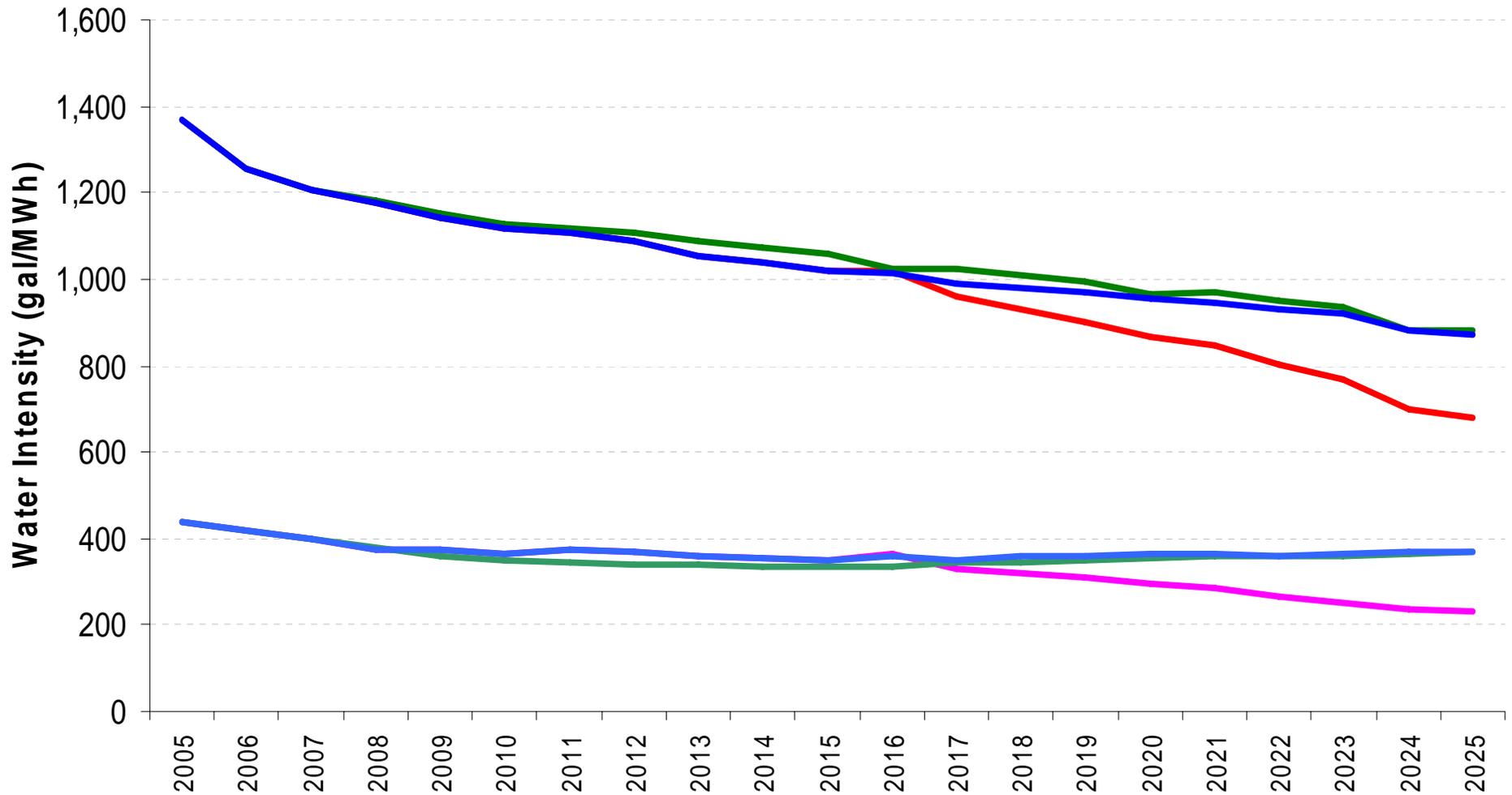
New NGCC: 130 gal/MWh

New Nuclear: 0 gal/MWh

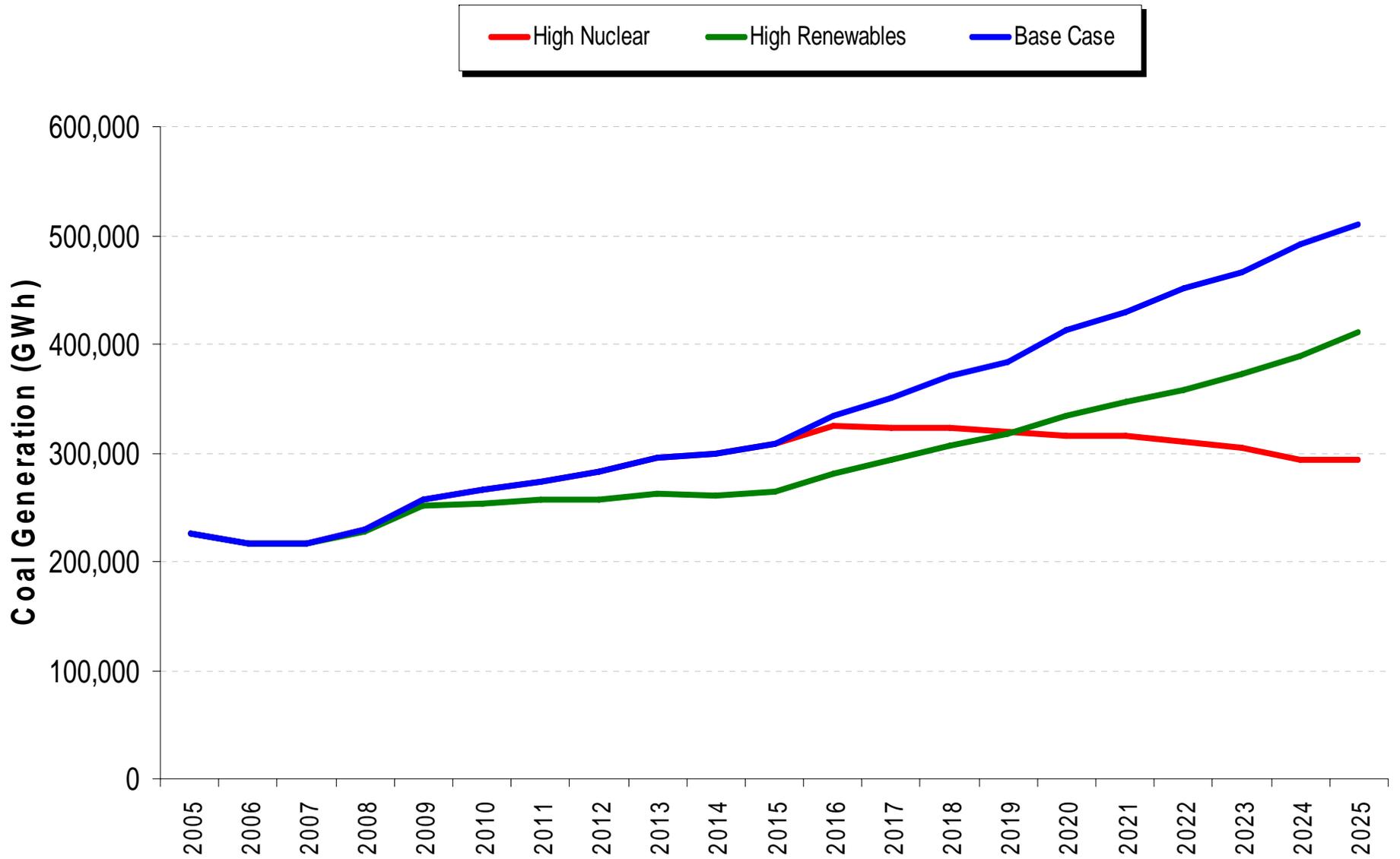
Water Usage Comparison



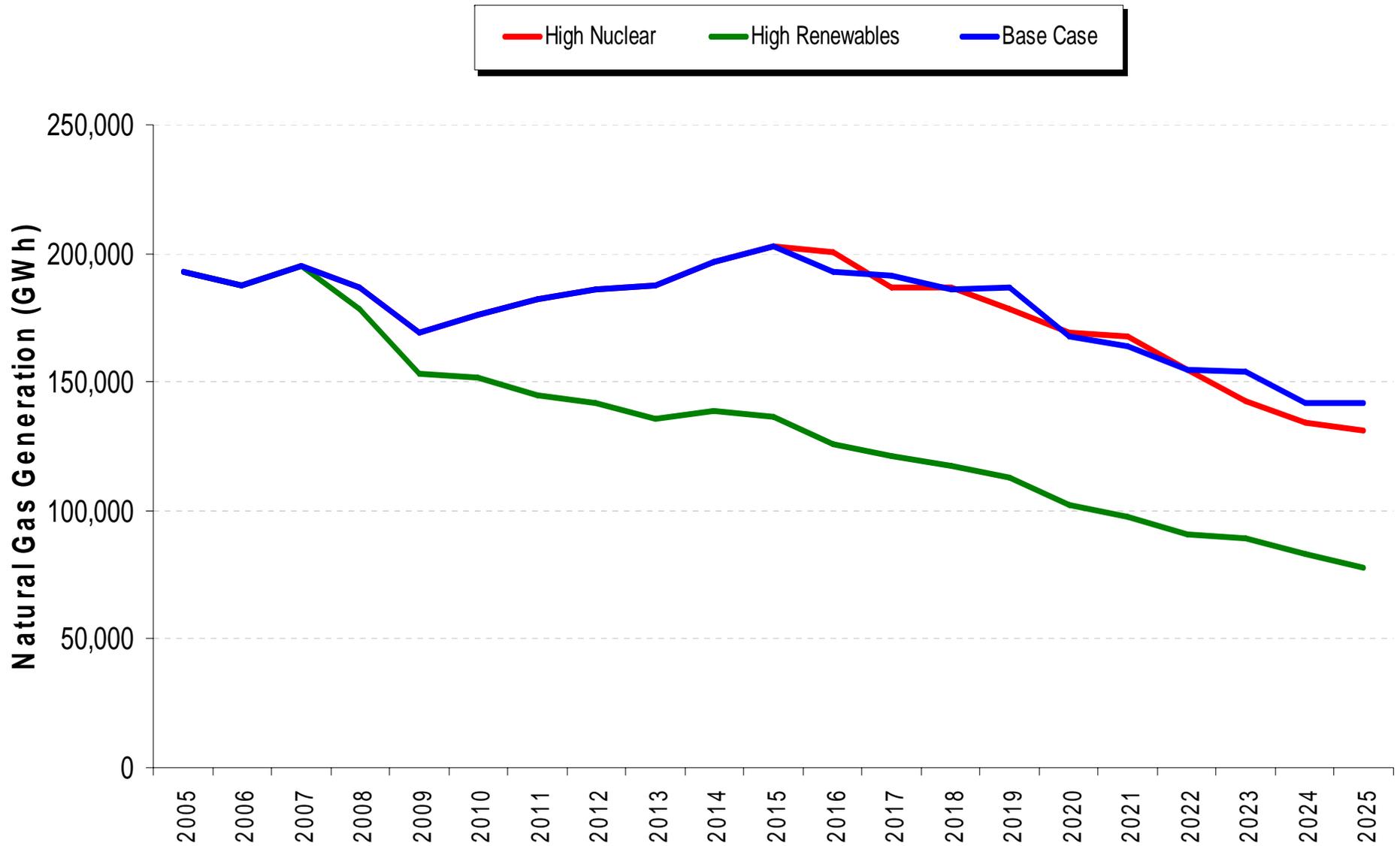
Water Intensity Comparison



Annual Coal Generation Comparison



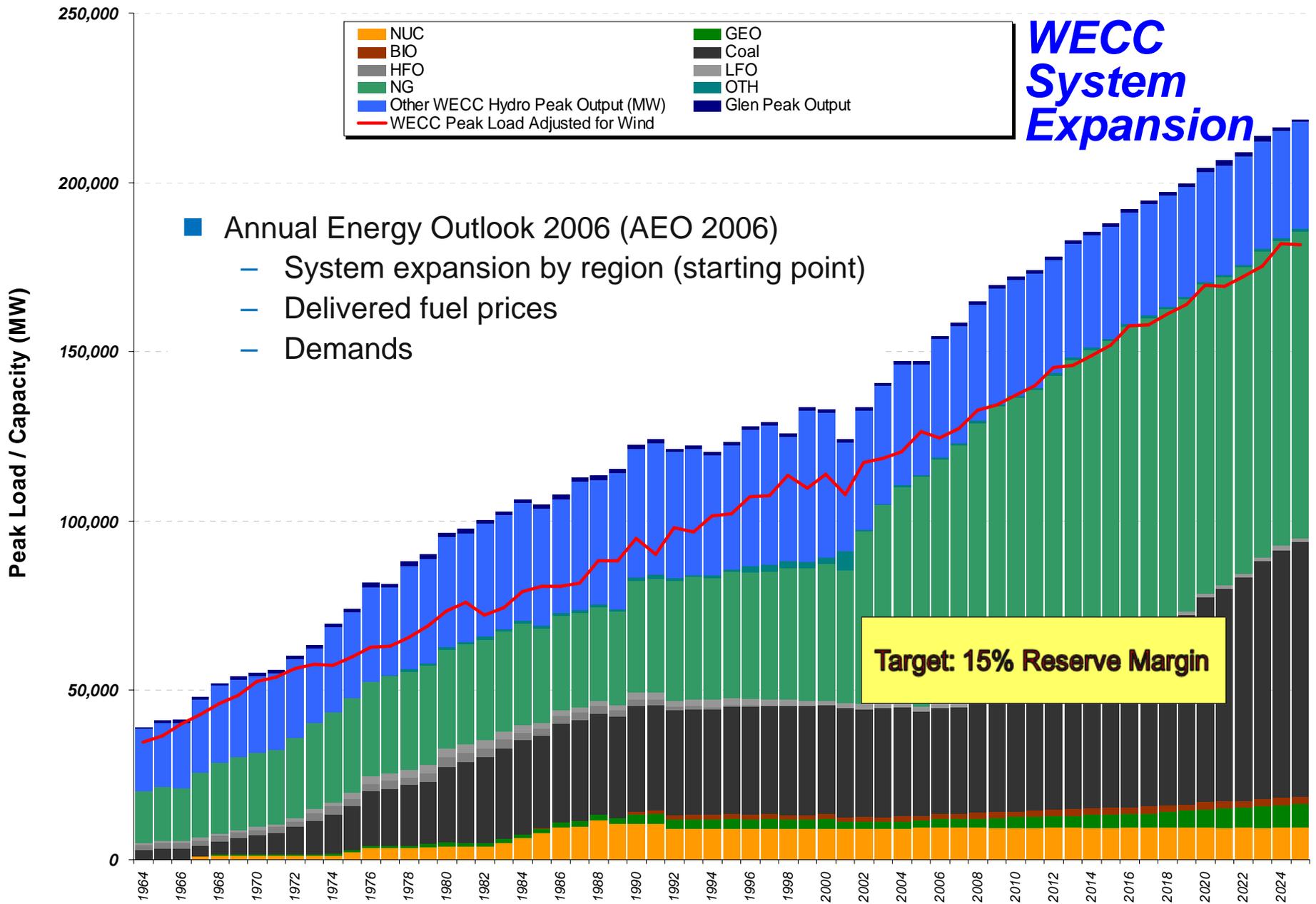
Annual Natural Gas Generation Comparison



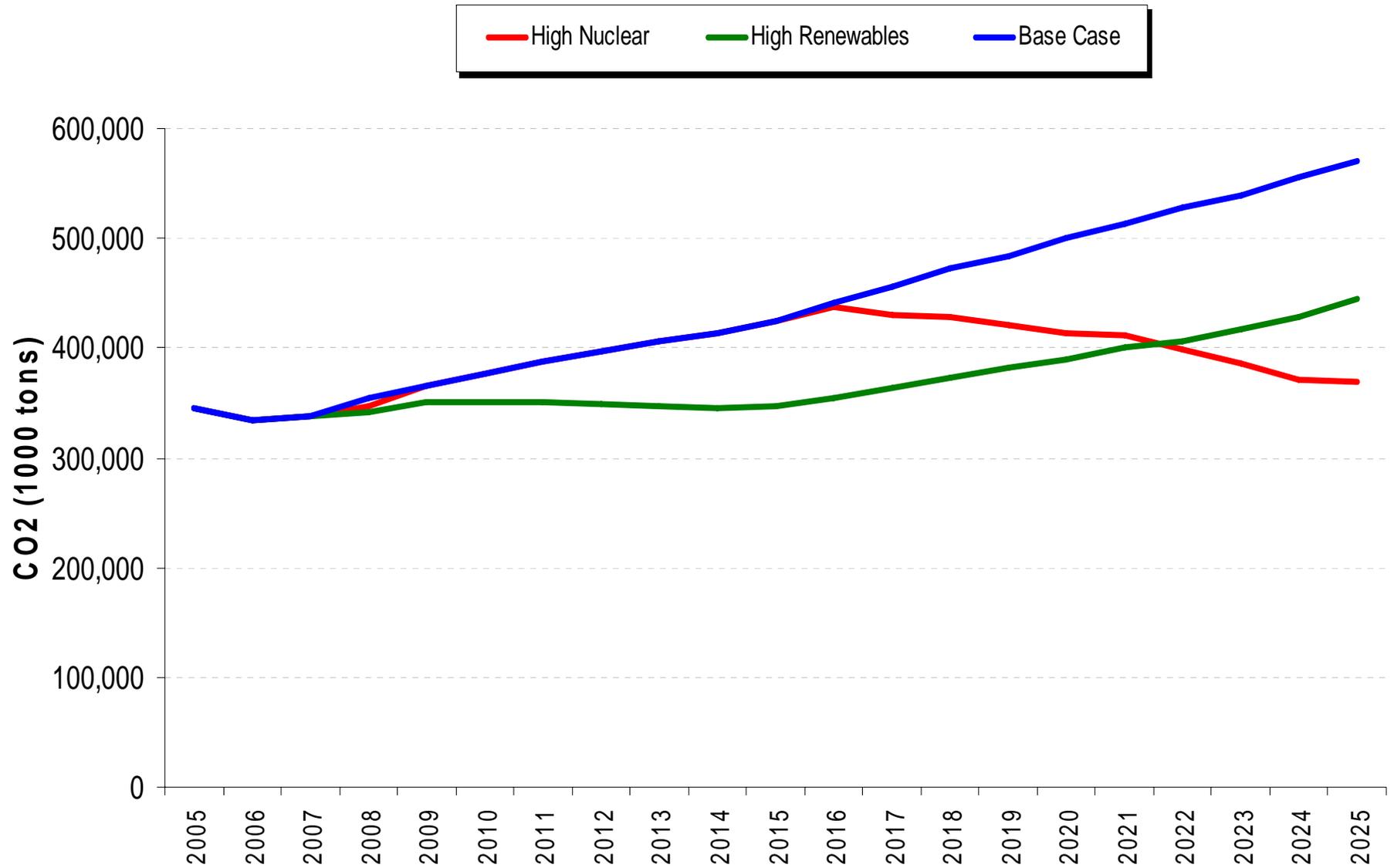
Summary

- Base Case water withdrawal is expected to initially decline and then increase slightly through 2025
- Base Case water consumption is expected to significantly increase in the longer-term, but at a rate lower than load growth
- Water intensity for power generation is expected to decrease over time as new technologies are brought on-line
- In the High Renewable Scenario, wind generation displaces both coal and natural gas-fired generation to moderately reduce water use
- In the High Nuclear Scenario, nuclear generation displaces base load coal generation resulting in a delayed, but more rapid reduction in water use
- Using a systems analysis approach provides valuable insights since it shows how all parts of a system respond when one or more components change

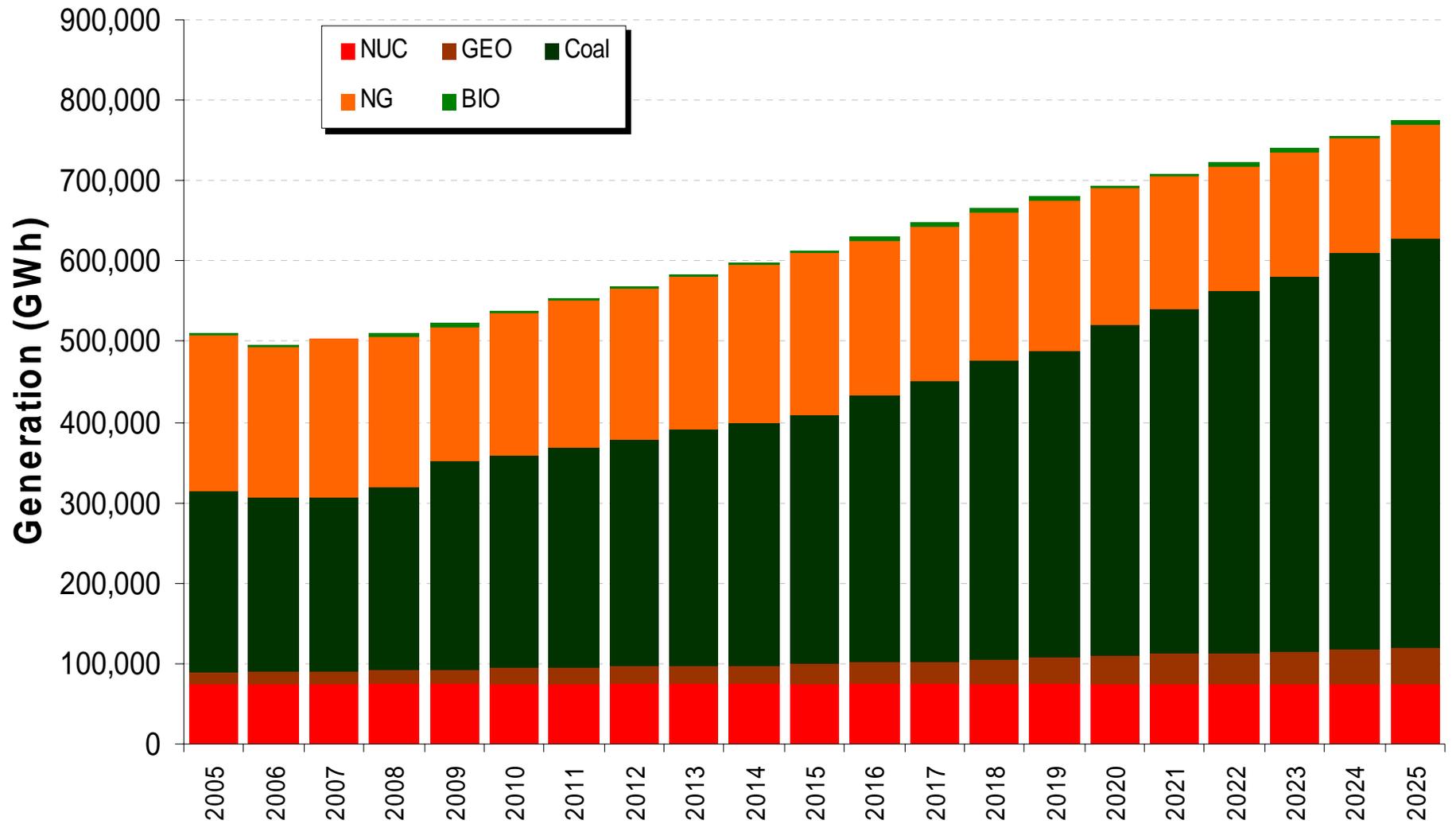
Supplementary Slides



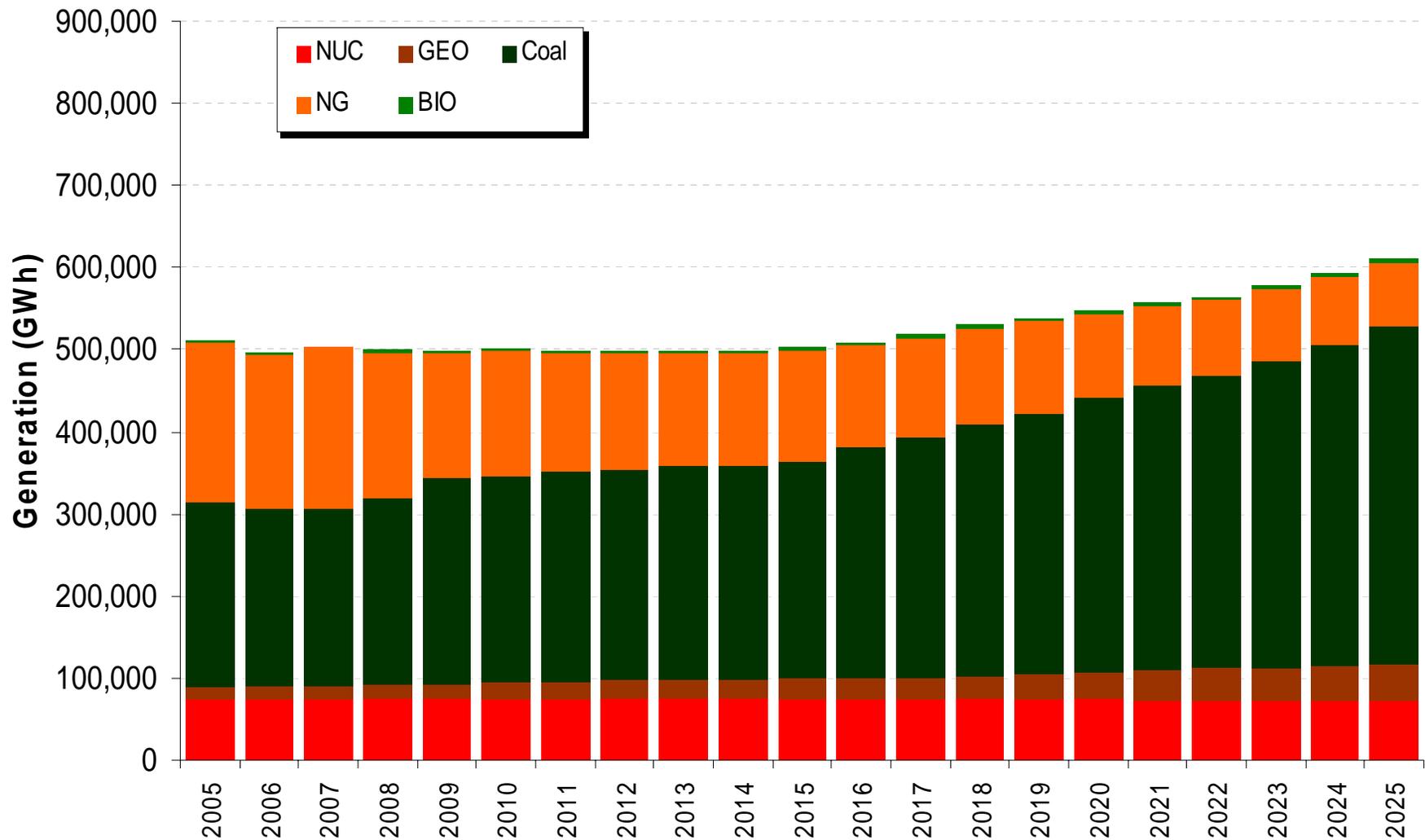
CO2 Emissions Comparison



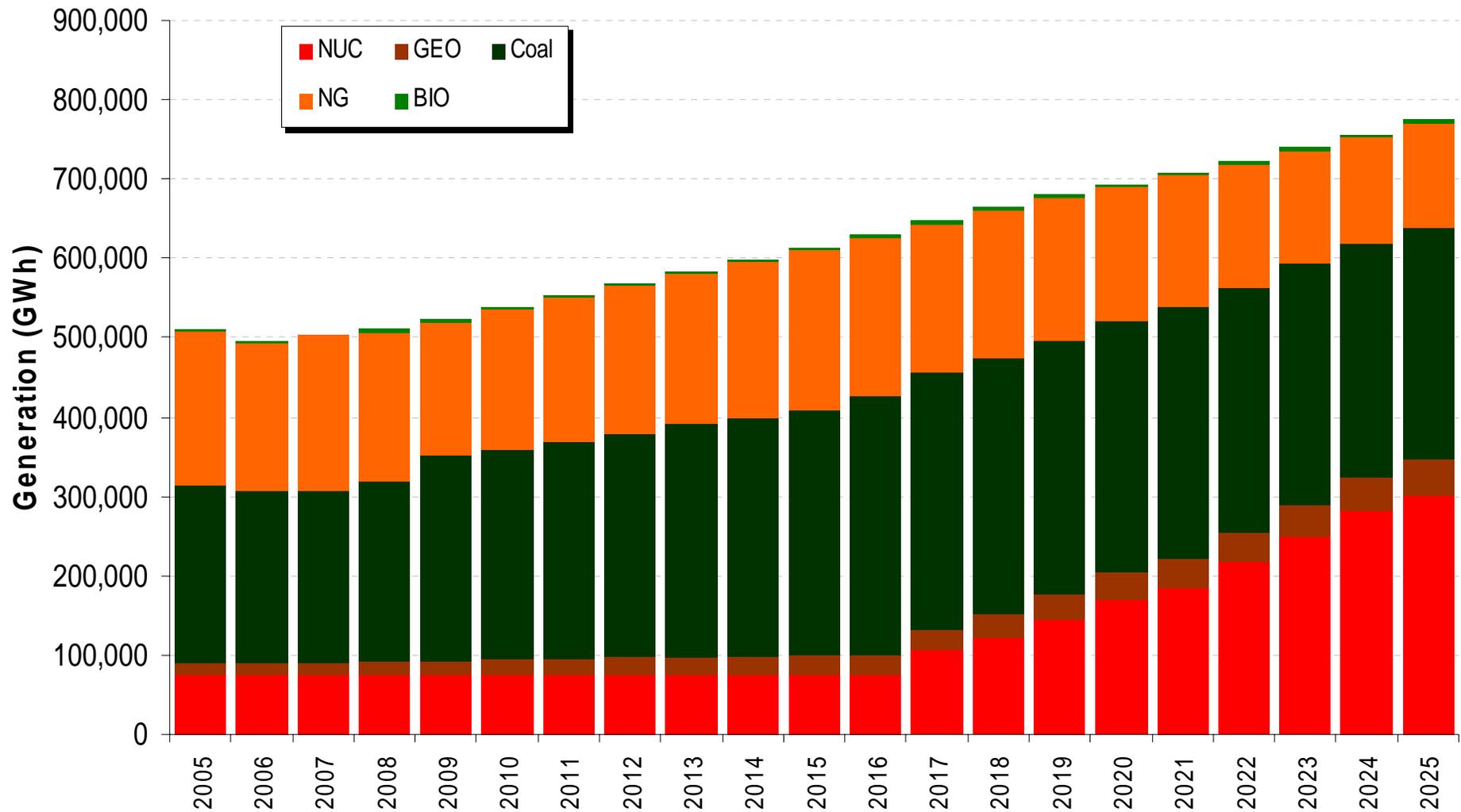
Base Case Scenario Annual Generation



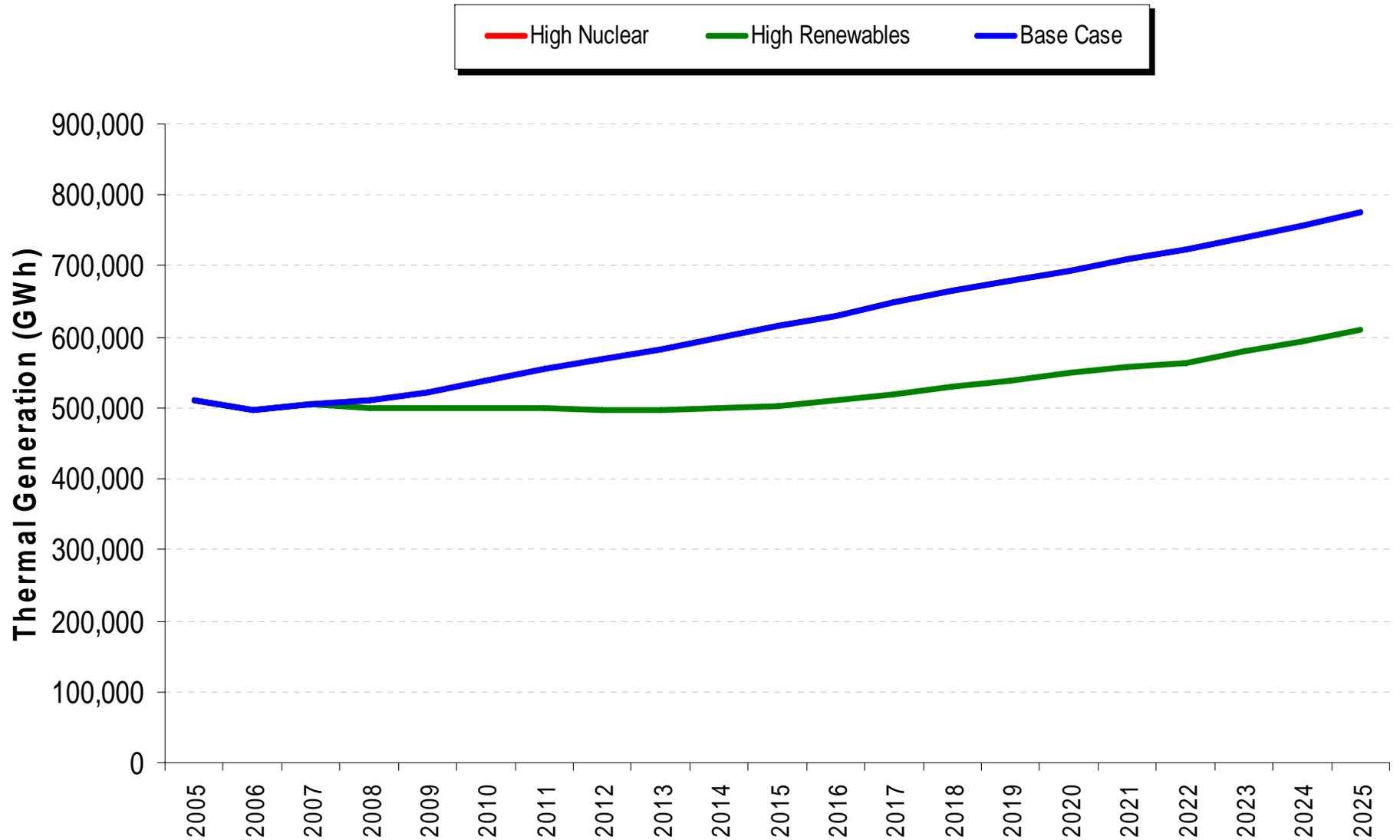
High Renewable Scenario Annual Generation



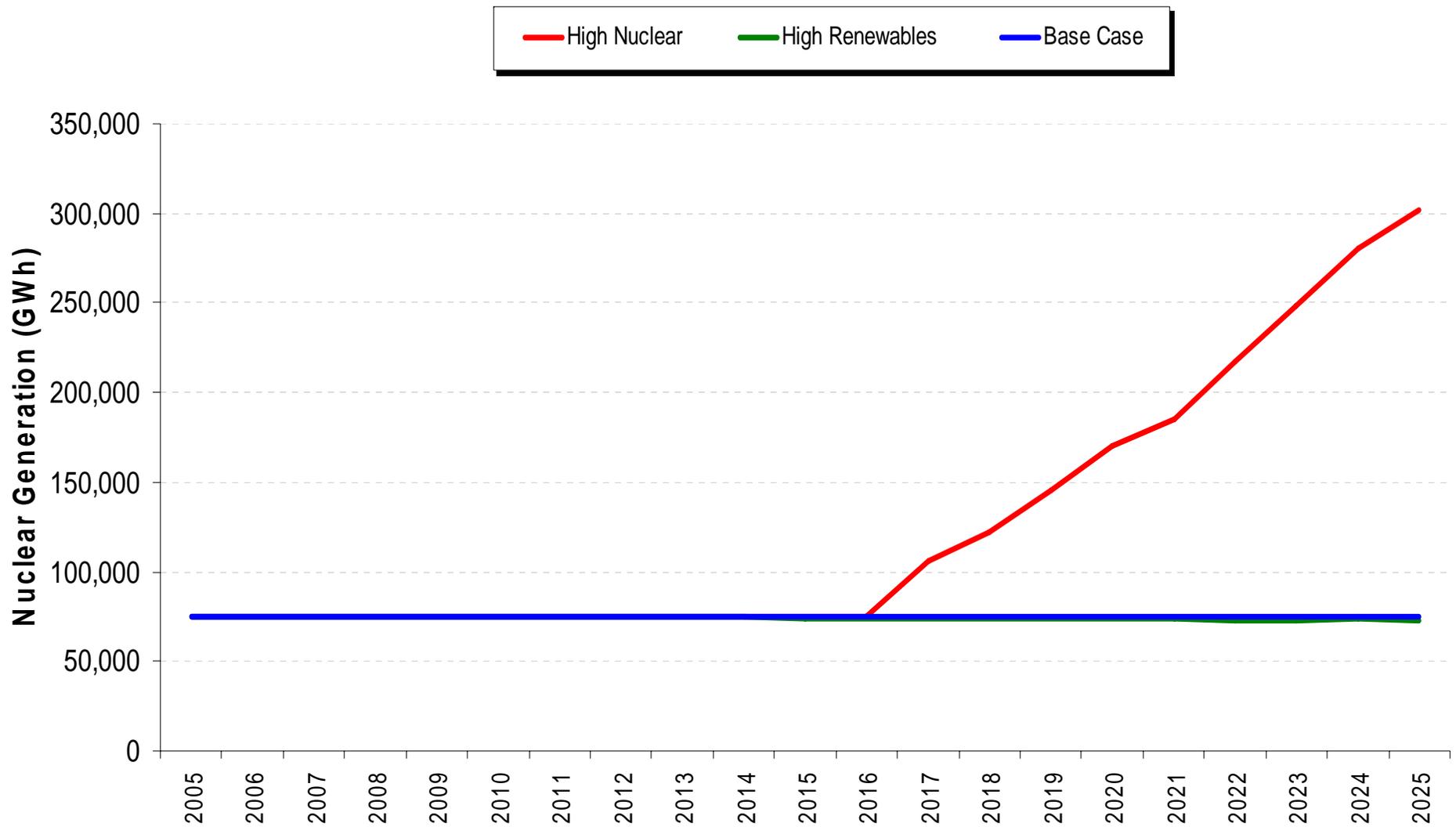
High Nuclear Scenario Annual Generation



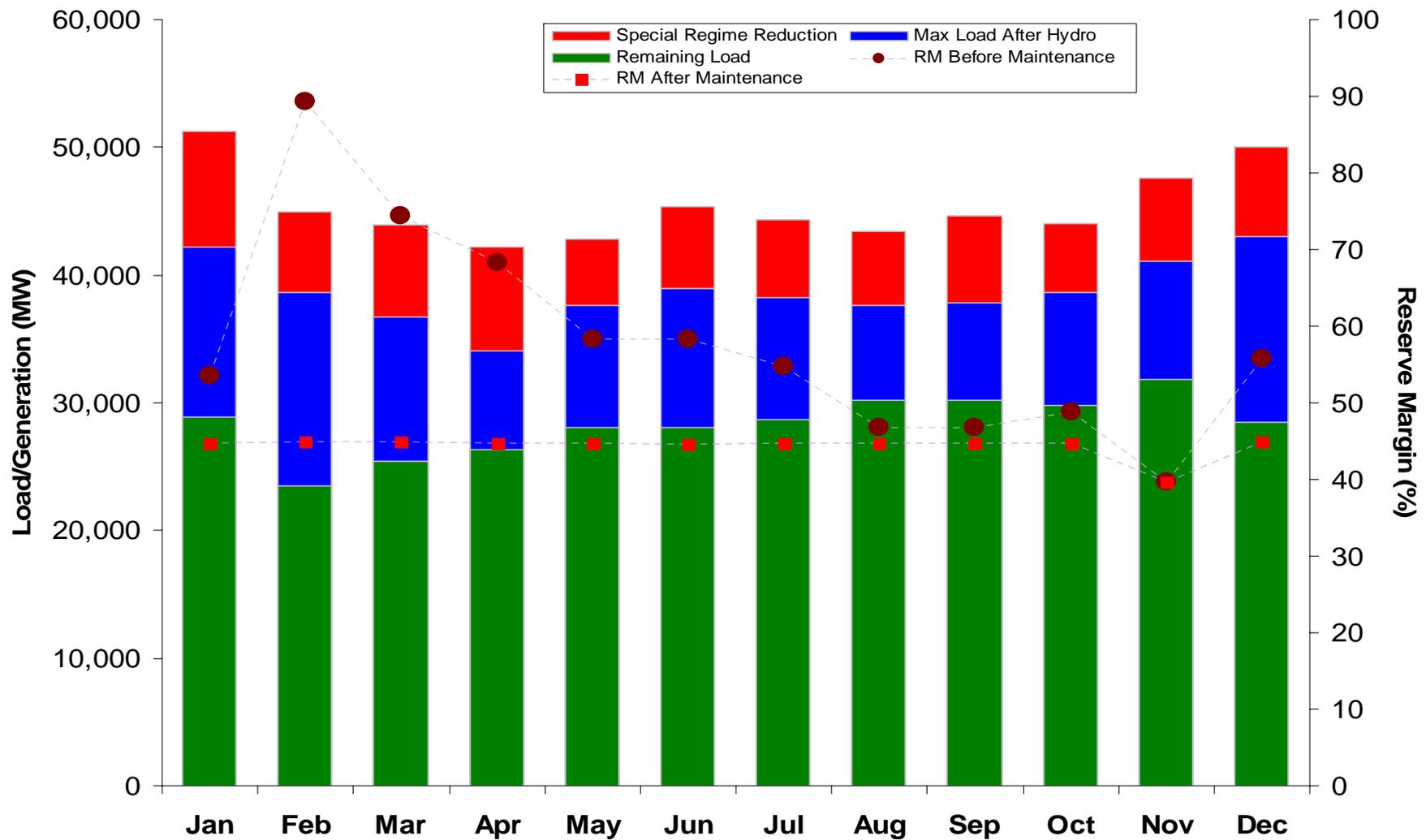
Thermal Annual Generation Comparison



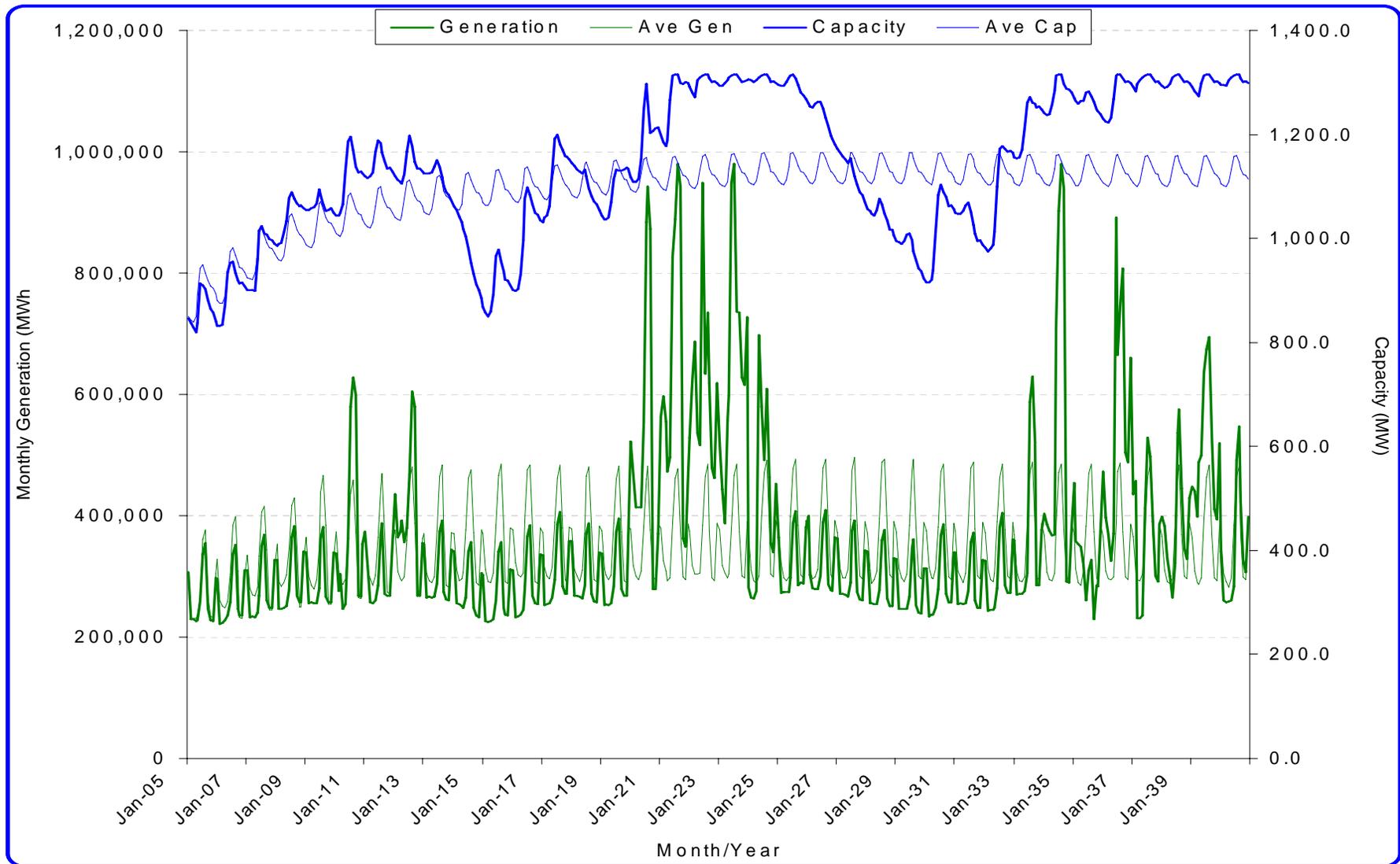
Annual Nuclear Generation Comparison



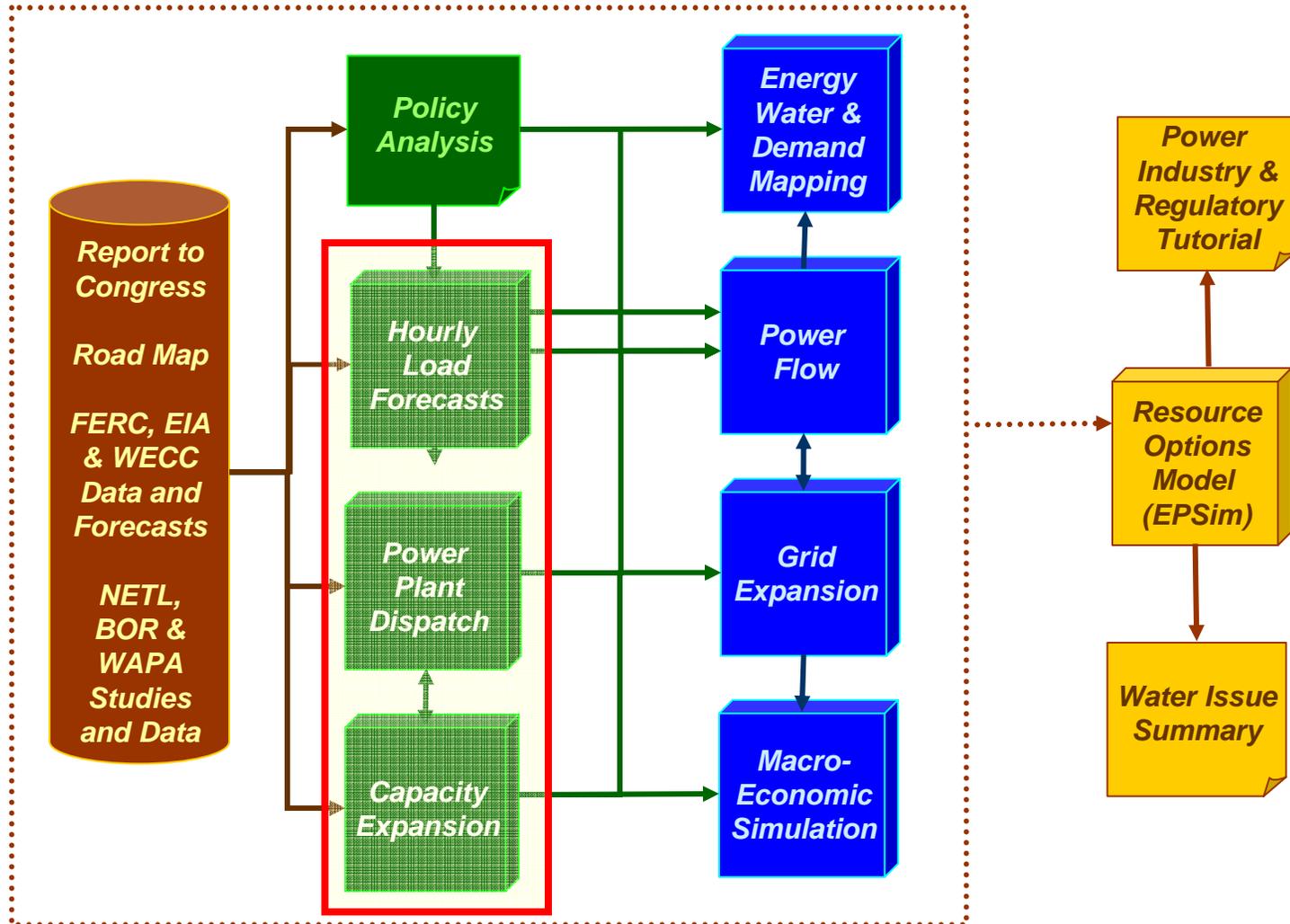
Maintenance Schedule: (Maximize the Smallest Reserve Margin)



Example of Hydropower Variability for Glen Canyon Dam

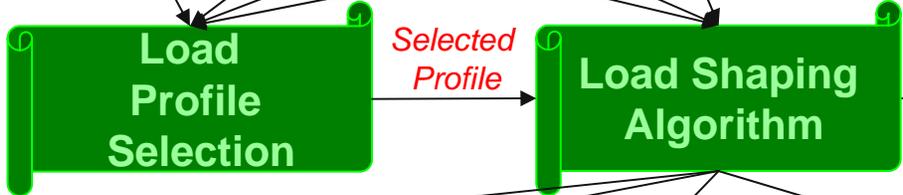
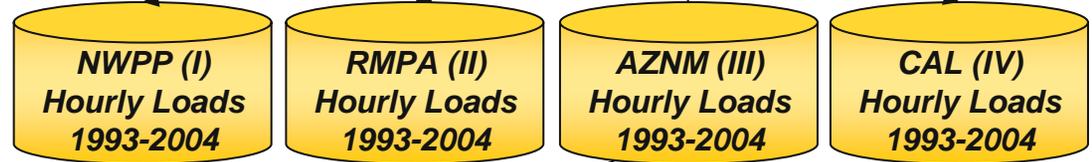
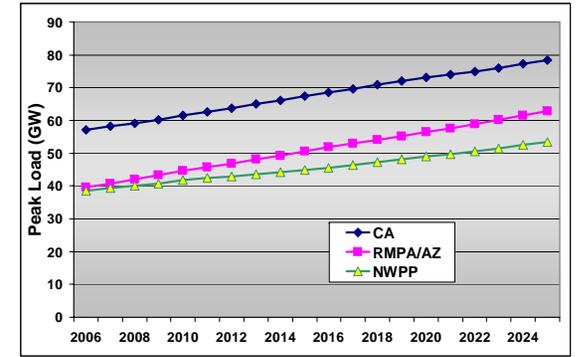


ANL Tools Were Integrated with SNL & LANL Models

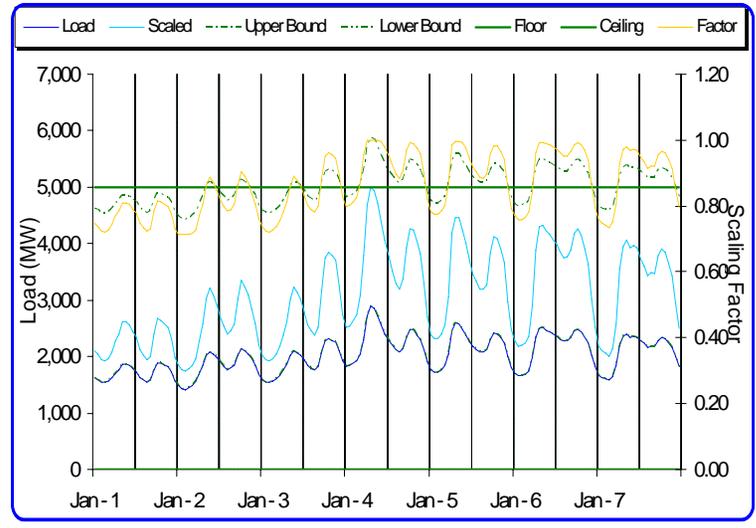
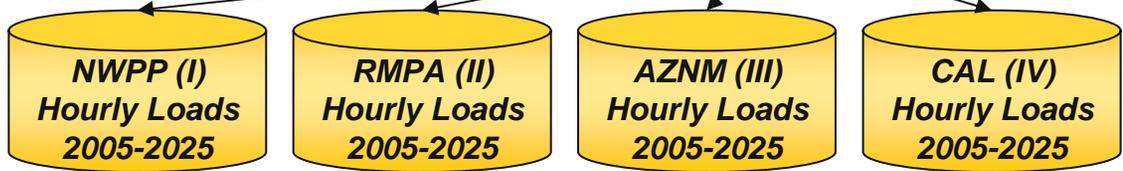


Hourly Loads Forecast

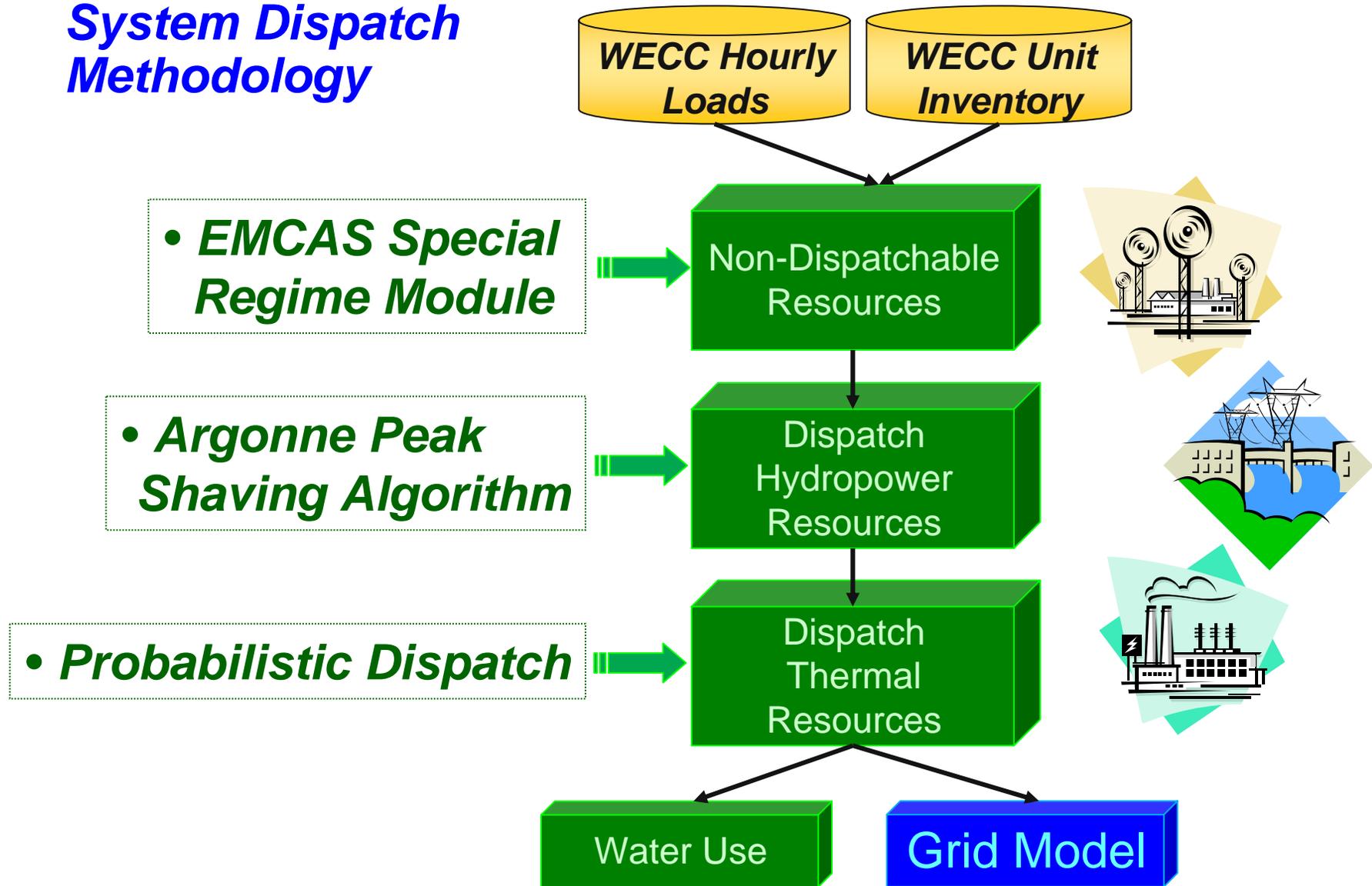
Control Area Loads Are Separated into Power Pools & Aggregated Hourly



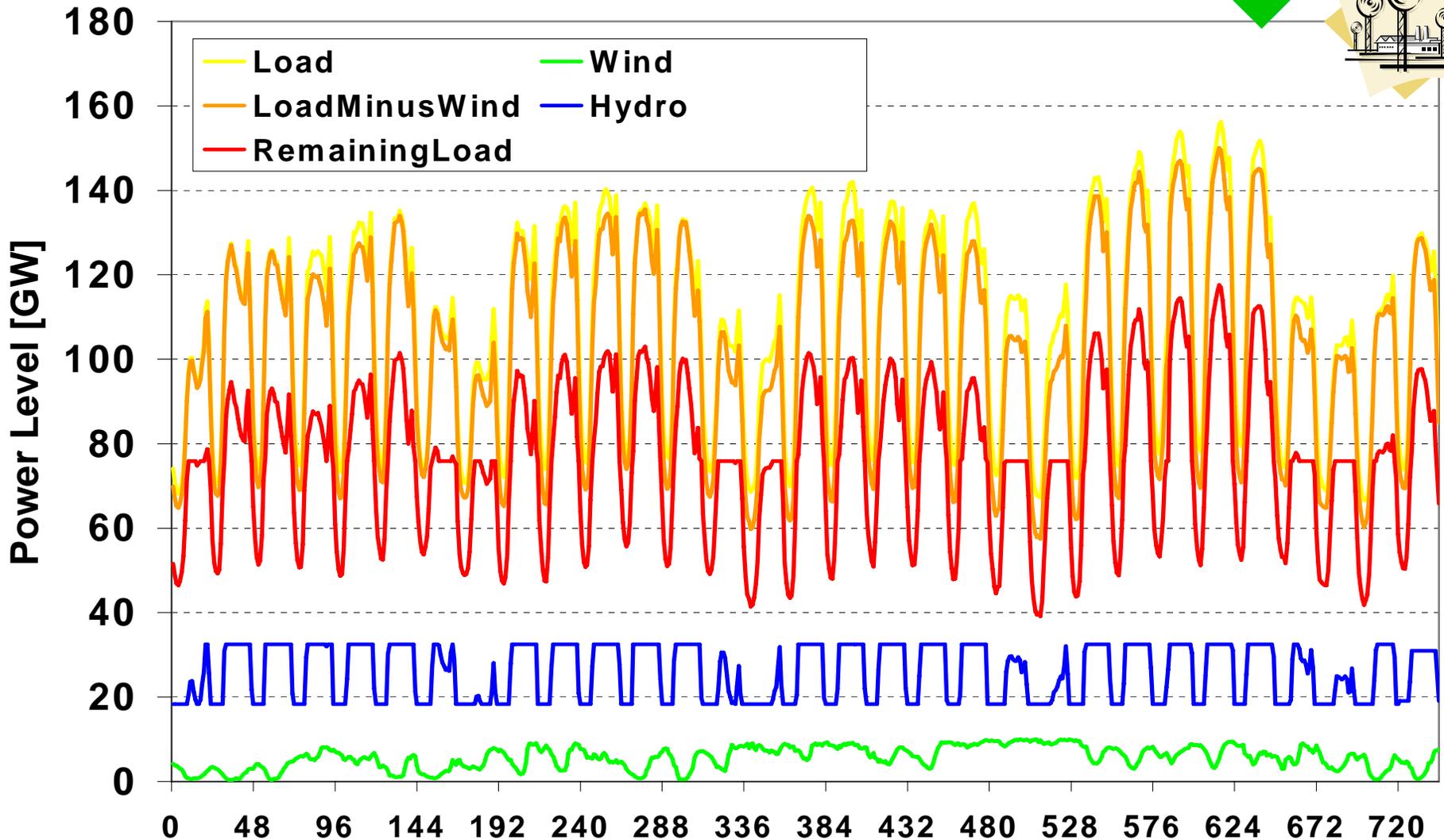
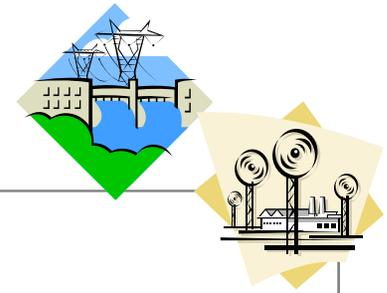
Monthly Load Control Totals (Peak & Total Energy)



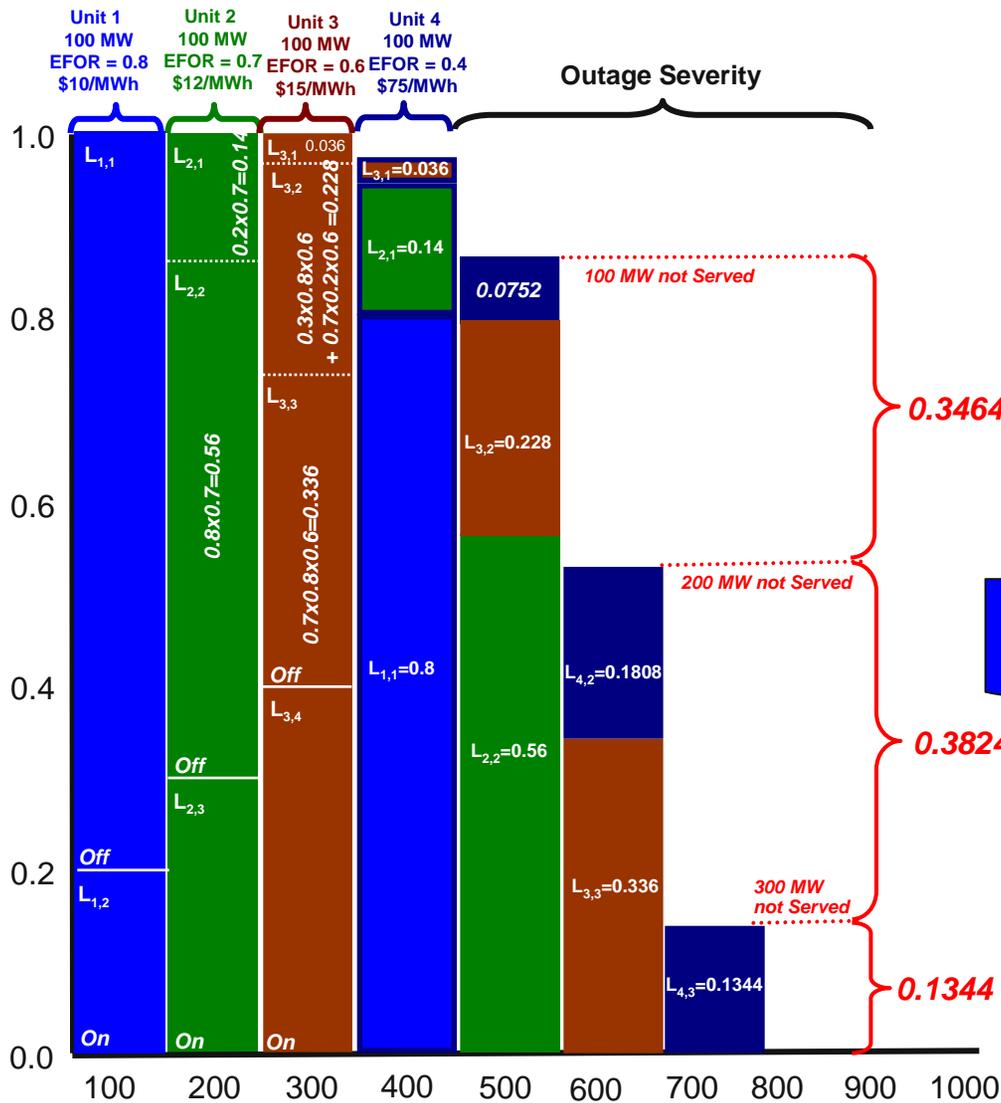
System Dispatch Methodology



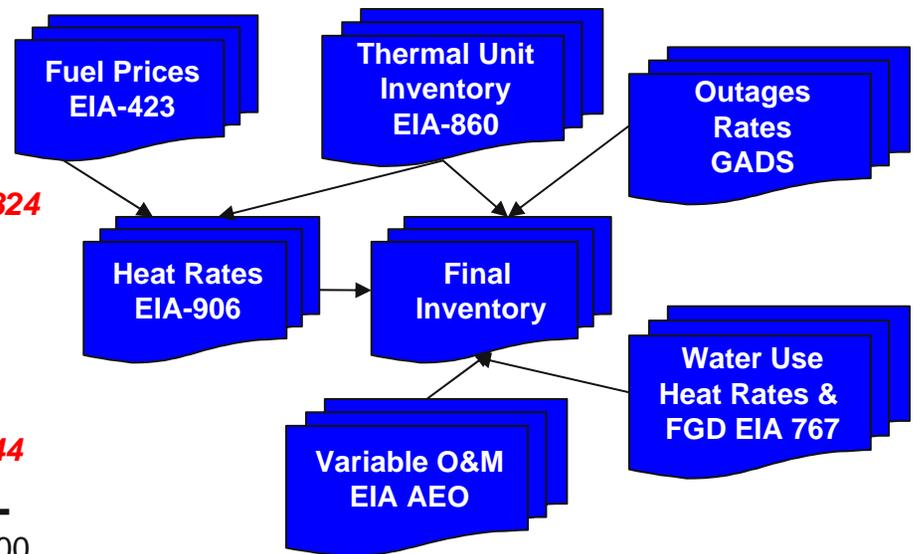
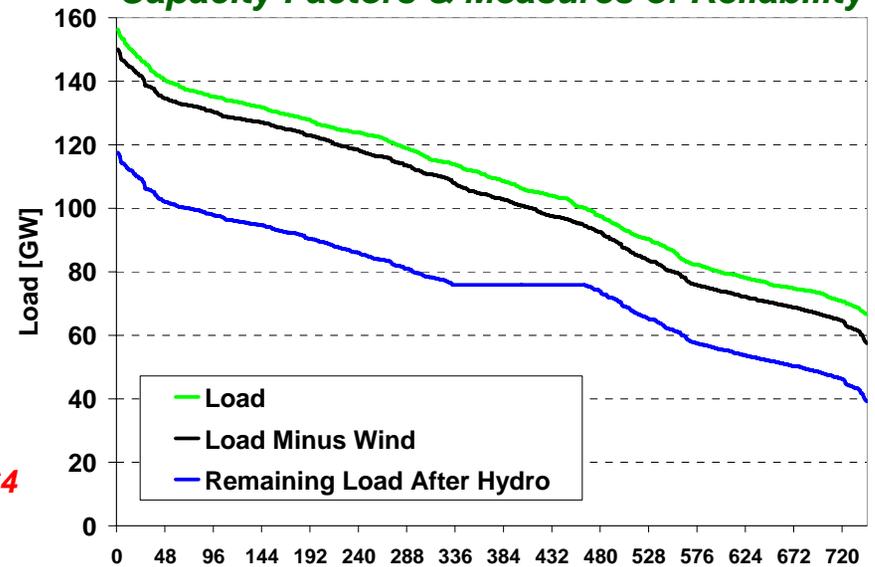
Loads Are Partially Served by Non-Dispatchable and Hydropower Plant Generation



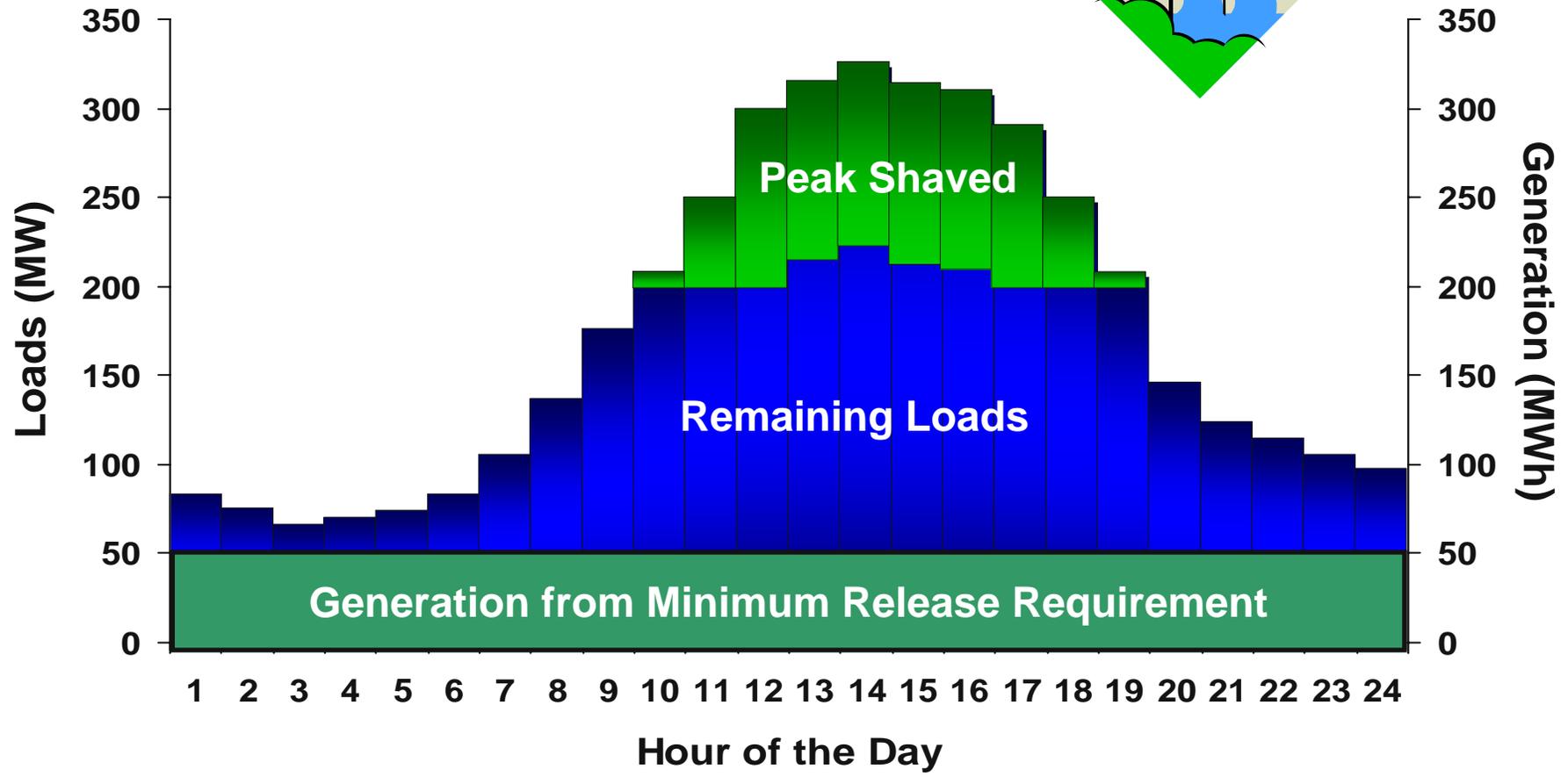
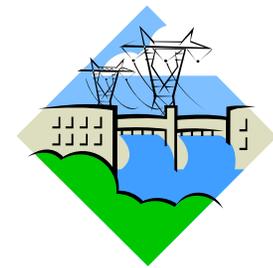
Thermal Unit Inventory Assembly & Dispatch



Baleriaux-Booth Convolution Computes Capacity Factors & Measures of Reliability

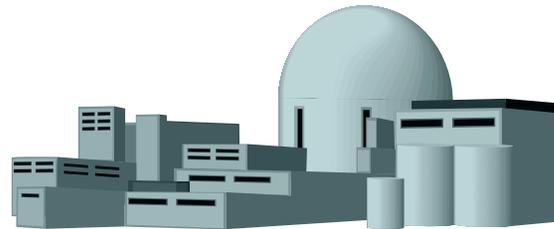


Hydropower Plant Operations Are Simulated by the Peak Shaving Algorithm

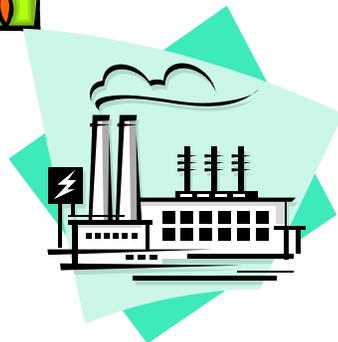


Thermal Power Plant Water Use Computation

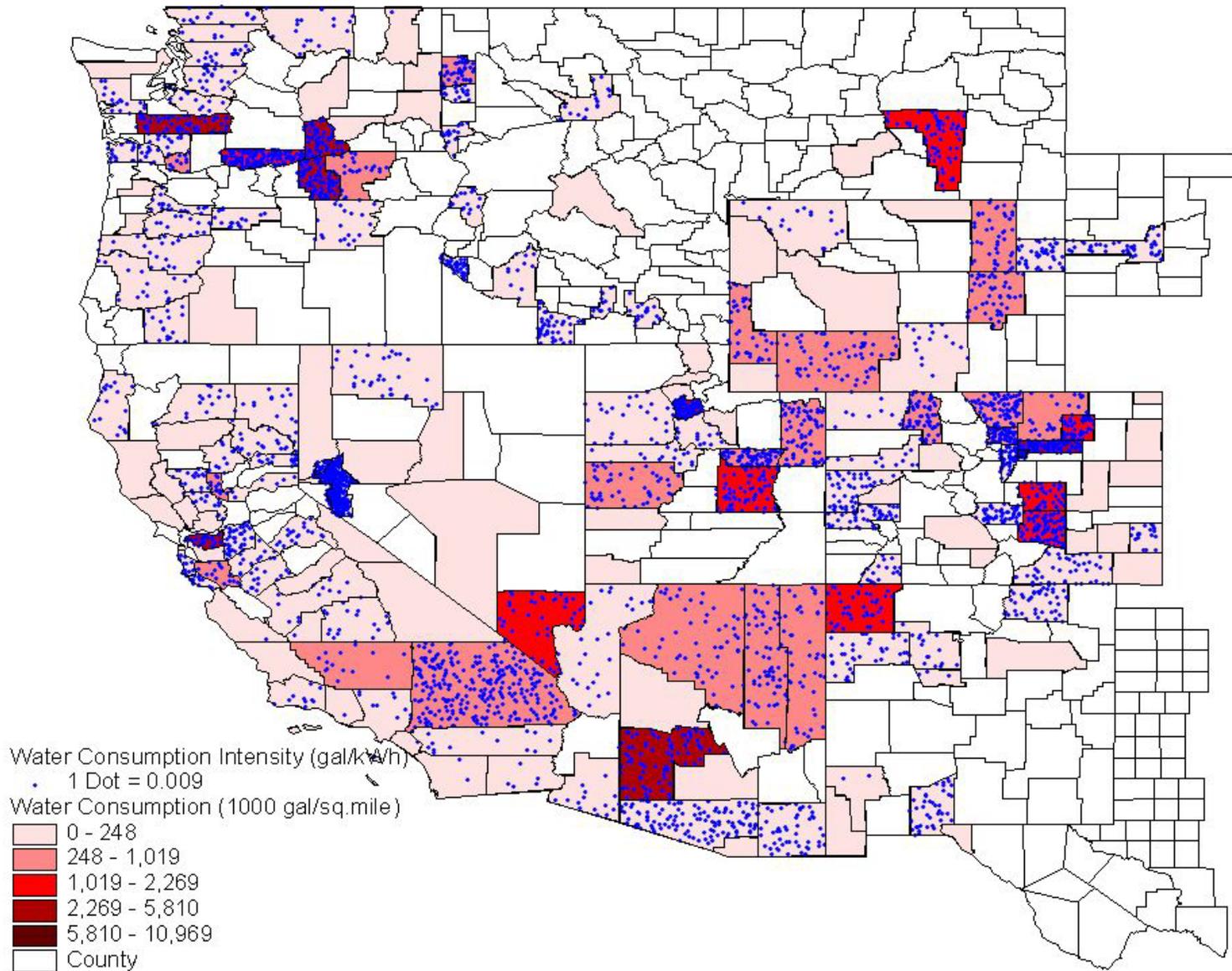
- Water consumption and withdrawal are based on water use factors and power plant energy production
- Water consumption factors is derived at the plant level from data contained in form EIA-767



***Measures for Other Metric Are Also Computed
(e.g., Air Emissions & Fuel Consumption)***



2005 County-Level Water Consumption



2005 County-Level Water Withdrawal

